TIMBER

TIMBER

A COMPREHENSIVE STUDY OF WOOD IN ALL ITS ASPECTS

COMMERCIAL AND BOTANICAL

SHOWING THE DIFFERENT APPLICATIONS AND USES OF TIMBER IN VARIOUS TRADES, ETC.

TRANSLATED FROM THE FRENCH OF

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PREFACE

"FRANCE will perish for want of wood"—thus spoke Colbert. This great Minister's words, which have been so frequently quoted, may notwithstanding find their place at the beginning of this work, when they will only serve to show of what importance the study of wood in general, of its applications, properties, and preservation can be. By speaking thus Colbert showed that he thoroughly grasped how important the employment of this precious vegetable could be to his country; he also manifested how he deplored the heedlessness of his contemporaries, as likewise the wasteful way in which they exploited the forests.

The forests were for a long time considered as vestiges of barbarity—as a sort of natural and savage richness which could be made use of according to the immediate needs of consumption, without taking thought as to the reproduction of them. There are even now countries where wood is sacrificed to the roughest usages, or where, to use an historian's expression, "Two pine-trees are hewn down to make a pair of wooden shoes," where, at any rate, forests are subject to complete destruction by the immoderate grazing of animals.

In our old Europe, where the abundance of forests was formerly so freely spread; upon the Spanish soil, formerly shadowed by Tugian and Castulonian Forests, and which to-day possesses but the last remains upon the sides of its mountains; in this France, whose mysterious forests Lucain traversed in the first century with strange terror, and which had been thinned by the axe of the Roman Conquerors; and also even in Germany, where, from the Rhine to the Carpathian Mountains, the celebrated Hercynian Forest formerly existed, of which the Black Forest, the timber of the Harz and the Erzgebirge are the last remains—to-day the hand of man has used, in such a manner and for so long, the treasures of Nature without foresight that the greatest preoccupation of cultivators of forests—the question which ought to attract the attention

of Governments most—is the replanting with trees of the land once occupied by forests.

Our human societies have exhausted this soil, which nourished them for centuries. Being unable to find in Europe sufficient quantities of wood necessary for the thousand-and-one requirements of civilisation, European nations import from far-off countries the rich products of their virgin or sparsely-inhabited soil, and in the meantime the clearing away of forests and the short-sighted destruction of this work of centuries has not been arrested upon this impoverished soil. The evil is as threatening as ever. The consequence of this baneful destruction has been not only the dearth of timber,—strictly, importation can, at least for a time, remedy this,—but the climate and the meteorologoical and physical conditions of our countries have been very seriously modified, and everybody who, concerned about the future, has allowed himself to reflect upon the present has regretted our ancient forests, and has witnessed with consternation the little that remained of them progressively cleared away.

Writers have already raised an alarm and shown that in a relatively short space of time mineral combustibles would be totally exhausted in Europe; and what has been said of the mineral fuel has been repeated by far-seeing individuals with regard to the wood. Trees are dwindling away, our forests are becoming depopulated, and while the countries of the North are comparatively well supplied with forests, yet the Southern countries of Europe are witnessing the disappearance of their timber.

In the sixteenth century—when French soil possessed forests and when coal was unknown to our hearths and industry—Bernard Palissy wrote:

"And when I consider the value of the smallest spots planted with trees or brushwood, I am quite astonished at the ignorance of man, for it appears that to-day he only studies how best to destroy the beautiful forests that his predecessors guarded so sacredly. I would not object to their cutting down forests provided that they afterwards replanted portions of them; but they do not think in the least about the time to come, nor do they think of the trouble they are bringing upon their children in the future. I cannot abhor sufficiently such a thing; nor can I call it a fault, but a curse, and a misfortune to the whole of France, for after all the trees have been cut down it will be necessary for all the arts to cease."

Advice follows this criticism, and this great man adds:

"If ever I became lord of such land that is devoid of wood, I

would compel all of my tenants to sow at least some portion of it. They are very poor; this is a revenue which comes without working for it."

Then a little further on:

"Do you think that this is of little moment to the prudent man, who will consider the usefulness of wood and who, above all things, will study in order to get it as his heritage? What would you do without wood?"

We shall see later on, in the course of this study, that, though Europe in general shows great dearth of wood and an ever-increasing insufficiency of its forest products, yet, on the other hand, from the other side of the Atlantic, on the American continent and in Australia, an abundance is contemplated which has been accumulating for centuries, and which has been but slightly cultivated. The Universal Exhibition of 1889 was a striking manifestation of the part which the human industry can reap from this opulence. There is in this an important reserve destined to provide for the wants of all, and whose economic importance recalls to mind once again the words of Bernard Palissy:

"I have often wished to make a list of the arts which would cease if there were no longer any wood, but when I had written down a large number of them, I found that there would be no end to the enumeration, and, after due consideration, I came to the conclusion that there was not even one trade which could be carried on without wood."

Economists are almost of one opinion as to the part which agriculture must play in the State, but they are far from being of the same mind about forests, whether they belong to private individuals or to the national domain.

This is not the place to take up the discussions which arise everywhere, constantly and periodically, as to the attempts to put the forest land to other purposes.

What we wish to prove (and that with great regret) is the indecision of men of authority to make known to the world their opinions upon this question of forests and the capital importance of this hesitation.

Everything which relates to forests feels the effects of this unhealthy state of things, and the clearing of the land of trees will continue until a second Colbert substitutes stern decrees for barren advice.

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PART I.

PHYSICAL AND CHEMICAL PROPERTIES OF WOOD.

CHAPTER I.

COMPOSITION OF THE VEGETABLE TISSUES—CHIEF ELEMENTS —M. FREMY'S RESEARCHES.

THE fibrous tissue of wood deprived by certain solvents of several foreign matters which it contains was for long considered to be purely an element. Payen, as a result of important studies, showed that this substance, looked upon until that time as of a pure, woody nature, is only a mixture of different bodies, and that it results from the juxtaposition of elongated cells containing in their interior a pure and amorphous matter, which is found in more or less regular layers.

Each cell of the wood may be considered as being formed principally of an exterior substance (to which Payen gave the name *cellulose*) and of an incrustated matter the composition of which appears to be complex.

The incrustated matter preponderates in hard wood: being very abundant in fruit-stones, it forms the stony concretions of certain pears. The elongated cells of the woody tissues enclose it in beds more or less thick. More abundant in the heart than in the sap-wood, it is often of a yellowish or brownish colour. Heavy and hard wood contains it in greater quantities than does white and light wood.

The incrustated matter of the wood can be extracted by grinding the latter for a certain time in a mortar; it is friable, and can then be separated by sifting; it is afterwards purified by means of alcohol. This matter contains more hydrogen than cellulose; its composition cannot be represented by carbon and water. As it possesses an excess of carbon

and hydrogen as compared with oxygen, its combustion produces more heat than that of cellulose, which is the cause of hard wood having a calorific power considerably higher than that of soft wood.

Incrustated matter is coloured black by sulphuric acid; it is soluble in chlorine water.

Payen discovered four chief elements in this matter, which are called *lignose*, *lignone*, *lignine*, and *lignorose*.

Lignose is insoluble in water, alcohol, ether, and ammonia; soluble in potash and soda.

Lignone, insoluble in water, alcohol, and ether; soluble in ammonia, potash, and soda.

Lignine, insoluble in water and ether; soluble in alcohol, potash, soda, and ammonia.

Lignorose, insoluble in water; soluble in alcohol, ether, potash, soda, and ammonia.

M. FREMY'S RESEARCHES.

Following the researches of M. Payen, M. Fremy applied himself to a series of important investigations of the chemical composition of vegetable tissues. M. Fremy succeeded in discovering several chief elements and in giving a new interpretation of the chemical constitution of vegetable organs.

We therefore propose to give a concise analysis of his investigation.

Instead of considering vegetable tissues as formed of a simple principle, *cellulose*, with properties varying according to the state of aggregation of organic matter and the incrustation of this substance by foreign bodies, M. Fremy established, in the new researches which are now set forth, that each tissue presents a chemical composition and special properties which depend upon the physiological *rôle* which it is called upon to play in vegetation.

In assigning to each tissue a special chemical composition, M. Fremy thus established a remarkable analogy between the constitution of vegetable organs and that of the tissues of animals. The bodies, which form the skeleton of the vegetable organs being all insoluble in neutral solvents, present great difficulties in their analysis, their purification, and also in the examination of their essential properties.

The judicious employment, however, of certain reagents—such as potash, sulphuric acid, nitric acid, hydrochloric acid, alkaline hypochlorites, and the ammoniacal-copper reagent — permits even of the accomplishment of an immediate analysis as complex as that of a stem.

Cellulose Bodies.

We give, with M. Fremy, the name of " Cellulose Bodies " to a collection of direct principles which are met with in the majority of the elementary organs of plants, sometimes in the state of purity, but more often associated with other substances, organic or mineral.

Cellulose bodies constitute utricular membranes, fibres, hairs, etc. All cellulose bodies had been, prior to M. Fremy's researches, confused together and studied under the name of *cellulose.* They are linked to one another by specific characteristics of the same order as those which unite gums, sugars, amylaceous matters, albuminous bodies, etc.

These bodies are isomeric; the action of reagents brings them back again to the same state. Their general formula is:

$$C_{12}H_{10}O_{10}.$$

Amongst these we are able to distinguish:

(1) *Xylose*, which is found in cotton, in cortical fibres and in the utricular tissue of roots, leaves, flowers, and fruits. This direct principle is characterised by its solubility without coloration in cold concentrated sulphuric acid, by its solubility in warm hydrochloric acid, and by its insolubility in potash, nitric acid, and the hypochlorites.

(2) *Paraxylose* constitutes certain utricular tissues, such as that of pith, which is insoluble in copper reagent, but which becomes transformed into xylose under slight influences.

(3) *Fibrose* exists in the fibres of wood; reagents act on it very slowly.

(4) *Medullose* consists of cells of medullary rays, and has great analogy to fibrose; it is more changeable under the influence of alkalies and nitric acid.

(5) *Dermose* constitutes epidermic cells; reagents modify it with greater difficulty than fibrose.

Cellulose bodies are recognised by the following properties:—

(1) They are insoluble in cold water, and do not swell in boiling water like amylaceous substances.

(2) They are soluble in ammoniacal-copper reagent; this action is sometimes immediate; on the other hand, cellulose compounds only become soluble in this reagent after having been subjected to heat, that of boiling water or the action of energetic reagents.

(3) Potash, which so easily swells amylaceous bodies, does not act upon cellulose compounds, or, at any rate, only dissolves them as a hydrate in a state of fusion.

(4) Cellulose bodies are attacked but slowly by the hypochlorites.

(5) Monohydrated nitric acid, which reacts so rapidly upon cellulose bodies to form pyroxiline, does not exert any appreciable action over them when it is weakly diluted.

(6) Hydrochloric acid acts differently upon cellulose compounds: sometimes it dissolves them immediately, whilst at other times it only exerts over them a slow and incomplete action.

(7) The modifications which cellulose bodies experience under the influence of concentrated sulphuric acid are little known. It is known, however, that if a cellulose body is submitted to the action of an excess of sulphuric acid, and if the raising of the temperature cannot be avoided, the organic matter becomes transformed immediately into dextrine and glucose.

But if a cellulose substance is disaggregated by degrees by sulphuric acid poured out drop by drop, a double combination of sulphuric acid and of cellulose body is realised.

This combination is decomposable by water and then forms intermediary bodies which have little stability.

The body which is precipitated at once has the characteristics of an acid; it is soluble in alkalies and still retains the elements of sulphuric acid. Being very unstable, cold water decomposes it and transforms it into a gelatinous substance, which is neutral and insoluble in water, and which, like starch, can be coloured blue by the action of iodine.

It must not, however, be inferred that cellulose becomes transformed into starch, for, upon a comparative examination of this iodine combination and iodide of starch, it is found that these two bodies differ greatly. Iodide of starch has, as is well known, a certain stability in cold water, whilst the cellulose combination is immediately decomposed in it.

As to the distinctive properties of the different cellulose bodies, it may be pointed out that:

Xylose is, of all these substances, the one which is most easily attacked by all the reagents; the dissolving action which the ammoniacal-copper reagent[1] exercises immediately over xylose is sufficient to characterise it.

The characterisation of paraxylose is also a very easy matter.

Ammoniacal-copper reagent does not dissolve it; but when it is submitted to the action of acids, alkalies, and even to the influence of boiling water or to that of dried heat, it immediately becomes soluble in copper reagent.

Fibrose withstands the reagents which disaggregate or dissolve xylose

[1] This reagent is easily prepared by passing, for a short time, some air thoroughly deprived of carbonic acid over copper filings in concentrated ammonia.

and paraxylose; it is only attacked by the ammoniacal-copper reagent if it has been completely modified by energetic agents. Those alkaline solutions which dissolve xylose, paraxylose, and even medullose are without action upon fibrose.

Medullose has some relation to fibrose; but on submitting these two bodies to the action of the reagents, it is noted that medullose is always attacked more easily than fibrose.

Dermose, of all the cellulose bodies, resists the action of the reagents the most; thus, hydrochloric acid dissolves other cellulose substances very easily, but does not disaggregate dermose.

Concentrated sulphuric acid alone exerts an immediate action upon dermose.

Epiangiotic Bodies.

M. Fremy has also, in a general manner, described the chief elements very different from the preceding ones, and which, accompanying the cellulose bodies, are found abundantly in woody tissues.

Payen classified them as cuticle and incrustated matter, but M. Fremy demonstrated that these epiangiotic (ἐπί = upon; αγγεῖον = vessel) bodies differ from cutose and do not incrustate cellulose substances.

They differ from cellulose bodies by their composition and properties. If they are submitted to an elementary analysis, it is proved that they contain an excess of carbon and hydrogen, and that, consequently, they cannot be represented in their composition by carbon and water.

These bodies are insoluble in neutral solvents, but highly concentrated solution of potash attacks them more readily than the cellulose bodies.

Heat also modifies them more easily, and transforms them into ulmic acid immediately soluble in alkalies.

Sulphuric acid does not dissolve them, but, on the other hand, they are very soluble in hypochlorites.

Being attacked easily by nitric acid, they then become transformed into a yellow acid resin completely soluble in alkalies.

The cellulose membranes are generally covered by the epiangiotic bodies, but are not incrustated by them. Indeed, when, in a vegetable tissue, the cellulose bodies are removed by means of concentrated sulphuric acid, a residual tissue is obtained which has the first organisation of the original tissue to such an extent that, upon microscopical examination, it might be believed that the sulphuric acid has not carried off any substance. Nevertheless, upon operating upon the ligneous tissue, sulphuric acid dissolves more than 70 per cent. of the cellulose body.

This preservation of the form thoroughly proves that the epiangiotic bodies do not incrustate the cellulose membranes, but that they cover them. Epiangiotic bodies cannot be considered as giving hardness to cellulose ones by determining the adherence of the cells to one another, for it is rarely that one can prove their presence in tissues which often have the hardness of stone, as for instance in those of vegetable ivory.

Three epiangiotic substances can be distinguished, covering ligneous fibres, the cells of the medullary rays, and the vessels. They have received the names of *exofibrose*, *exomedullose*, and *vasculose*.

When they are submitted to the action of reagents, unquestionable differences are recognised in the reactions which are produced. Thus, alkalies modify vasculose more easily than exofibrose and exomedullose.

Exofibrose is more stable than the others. Vasculose constitutes the external part of the vessels. It is attacked by nitric acid and hypochlorites; concentrated potash modifies them equally.

The following procedure is adopted in order to prove the presence of cellulose and epiangiotic bodies in an organic tissue:—

The tissue is treated with concentrated sulphuric acid, which dissolves the cellulose bodies. This acid liquor, submitted to the action of water, permits of the settling of the cellulose bodies, which are coloured blue by iodine. The part insoluble in sulphuric acid is washed several times in boiling water, then treated with nitric acid or hypochlorites, which immediately effects the solution of the epiangiotic tissue.

Pectose.

This is a substance insoluble in water, alcohol, and ether, and which almost invariably accompanies the cellulose matter in the tissue of plants.

Being completely insoluble in water and alterable by a large number of reagents, it cannot be separated from the cellulose matter. Under the simultaneous influence of acids and heat, it becomes transformed into a body which is soluble in water, and taking the name *pectine*.

Pectose must not be confused with the substance which constitutes the vegetable cells; boiling for a few seconds is sufficient to change into pectine all the pectose contained in the pulps of roots or of fruit, whilst the cellulose matter does not give any traces of pectine through the action of acids.

As this substance does not directly affect our subject, we need not further consider it.

Cutose.

It has been admitted for some time that the epidermis is a part of the cellular tissue which it covers; this is true in a certain number of plants of very simple organisation, but generally the cells forming the epidermis are very different from the subjacent tissue.

This epidermis is composed of two very different substances. One, the more durable, is a thin pellicle stretching over the whole surface (Fig. 1). This pellicle has received the name of *cuticle.* The other, and more internal, is the epidermis, properly so called, composed of cells in juxtaposition, circumscribed by straight lines (Fig. 2) or by very flexuous lines (Fig. 3).

Fig. 1.

The cuticle leaves on incineration about one and a half per cent. of calcareous ashes.

It is insoluble in all the neutral dissolvents. It is not altered by diluted potash, ammonia, ammoniacal-copper reagent, boiling hydrochloric acid, nor by sulphuric or nitric acids employed cold. It possesses a very marked elasticity when it is dried.

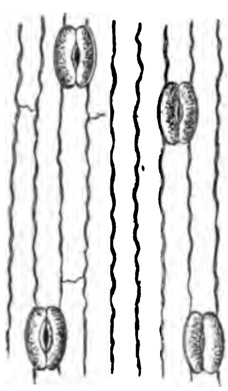

Fig. 2.

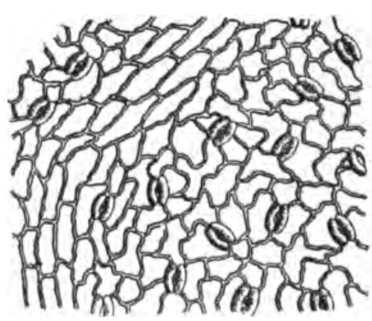

Fig. 3.

It presents, upon being analysed, the following composition:—

	Per cent.
Carbon	73·66
Hydrogen	11·37
Oxygen	14·97
	100·00

This composition connects the cuticle with the fatty bodies.

It is evident from the studies relative to this subject to which M. Fremy applied himself, that the epidermic cells of plants are covered by a membrane having as its basis an element which has received the name of *cutose.*

This substance has many analogies with fatty bodies; like them, it becomes saponified; it resembles them equally in its elementary composition and in the derivatives which it produces under the influence of heat or by the action of nitric acid; but it differs from the fatty substances by its complete insolubility in ether and by the membranous aspect which characterises it. It is therefore a separate substance, whose properties are well adapted to the physiological *rôle* which it must play.

SUBERIN.

The substance constituting the suberic cells is a special principle, called by Chevreul *subérine.*

Suberin preserves the appearance of cork, from which it is extracted. Submitted to distillation, it gives a small quantity of water, then an oily colourless liquid, a lemon-coloured oil, and also a brownish-red oil, finally a small quantity of ammonia, a crystallisable fatty substance insoluble in water, and some gases. The residue is charcoal having the form of suberin, a quarter of the weight of the original substance.

Nitric acid rapidly changes suberin and transforms it into an acid which is insoluble in water, though soluble in alcohol and ether, presenting the greatest analogy to acid-resins and even to fatty acids.

Submitted to the action of concentrated potash, suberin undergoes a kind of saponification. Concentrated sulphuric acid does not appreciably alter it.

The chief elements composing the tissues of plants are not very numerous, those which are of interest to our subject being as follow:—

Cellulose bodies.	Pectose and its derivatives.	Suberin.
Epiangiotic bodies.	Cutose.	Mineral matters.

CHAPTER II.

ELEMENTARY ORGANS OF PLANTS AND ESPECIALLY OF WOOD.

UTRICULAR TISSUES.

ANATOMICAL CHARACTERISTICS OF UTRICULAR TISSUES.

THE utricle is a cavity equally distended in every direction. When these cavities can be developed freely, they take the form of an orb or of an ellipsoid (Fig. 4). If, upon the other hand, in developing they meet and press against each other, they finish by assuming the form of a polyhedron. In the latter case they recall to mind the cells of a honeycomb, and take the more generally adopted name of cells (Fig. 5).

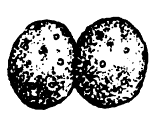

FIG. 4.

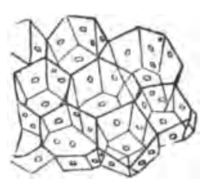

FIG. 5.

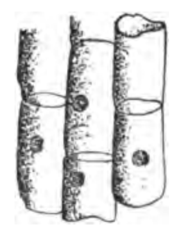

FIG. 6.

The utricular tissue is also called *parenchyma*. The polyhedral cells often assume the form of the cube, the four-faced prismatic column, and the dodecahedron.

Sometimes the cells do not present geometrical regularity. The angles are often blunt, the sides of the same square are not always equal, nor are the lines quite straight. The cells often have the appearance of a stump of cylindrical column (Fig. 6).

The walls of the cells do not always present the same appearance; sometimes they appear to be formed by a united and perfectly homogeneous membrane, at others this membrane is marked by a larger or smaller number of minute dots, when it receives the name of *dotted*

cell (Fig. 4). At times it has short lines, directed transversely or obliquely, when it is called *streaky cell* (Fig. 7).

When the internal membrane is broken irregularly more considerably, a regular network is then formed (Fig. 8), the gaps of which correspond with the points which the internal membrane stands in need of and the specks to the points where it doubles the external membrane; this has been designated by the name of *reticulated cell*.

Fig. 7.

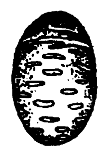

Fig. 8.

When we first commence to examine it, the cell appears as a small bag, formed by a perfectly continuous and homogeneous simple membrane, whose substance, at first soft and moist, dries and decreases by degrees. In this state it can continue to change in volume and form. It often forms a second membrane at a certain subsequent period over the whole interior surface of the bag.

The thickness of the walls of the cell can be successively augmented by the formation of a third layer, which forms upon the interior of the second, by a fourth upon the interior of the third, and so on.

Chemical Characteristics of the Epidermic Cells.

The epidermic cells almost always include a remarkable quantity of colouring matters and albuminous substances; they are seldom colourless, and generally contain nitrogenised elements, which often become insoluble by the action of reagents, and are strongly coloured by them.

Concentrated nitric acid immediately bleaches the epidermic cells; fibrinous membranes are dissolved and the utricular membranes remain uncoloured.

The substance constituting the epidermic cells has received the name of *dermose*. It is very stable, and resists the reagents, which dissolve and modify almost all the other principal elements. Thus concentrated nitric and hydrochloric acids only attack it with difficulty.

Chemical Characteristics of the Suberic Cells.

If the utricular membranes which constitute cork are examined with the aid of the microscope, one is led to believe that they show a

simple composition approaching that of the other vegetable cells; but if they are submitted to the action of reagents, it is recognised that their tissue is formed of two chief principles, namely, *suberin* and *fibrose*.

Their separation can be effected in the following manner:—If the cork is submitted to the action of concentrated potash, suberin saponifies and becomes dissolved, but fibrose is not attacked.

If cork is attacked by nitric acid, fibrose is not modified, whilst suberin is transformed into fatty acid, which can be afterwards easily dissolved by potash, alcohol, or ether.

As for fibrose, that can be dissolved, without coloration, in concentrated sulphuric acid.

Suberin has a certain analogy to cutose.

Chemical Characteristics of the Cortical Cells.

The fundamental tissue of these thick cells is fibrose. In order to dissolve it in ammoniacal-copper reagent, it is absolutely essential to treat it at first with acids. Sulphuric acid immediately dissolves the membranes of the bark.

The purification of the cortical cells often presents great difficulties, on account of the presence of green nitrogenised matters in the interior.

If pectose is associated with fibrose in the cortical cells, the former alone is eliminated on treatment with diluted acids, which transform pectose into pectine.

Chemical Characteristics of the Medullary Rays.

The membranes which form the cells of the medullary rays are made up of two chief elements. If, however, these cells are treated with concentrated sulphuric acid, it is observed that a part of the tissue is immediately dissolved in the reagent just as in the case of cellulose substances, whilst an insoluble membrane of a brownish colour remains.

This part, which is insoluble in sulphuric acid, is formed of exofibrose and exomedullose; the soluble portion is fibrose.

Inversely, highly concentrated potash, nitric acid, and the alkaline hypochlorites dissolve the bodies of the external membranes.

Separation is completely effected when fibrose immediately dissolves in concentrated sulphuric acid without furnishing a brownish coloration.

Chemical Characteristics of the Parenchyma of Pith.

Chemical action shows that the parenchyma of pith has not the same constitution as the medullary rays.

Ammoniacal-copper reagent, as a matter of fact, does not dissolve the parenchyma of pith immediately; it is necessary to raise the temperature to about 150° C. The chief principle constituting the parenchyma of pith has received the name of *paraxylose*. It must be added that the cells which constitute this tissue are not formed in part, like those of the medullary rays, by a substance insoluble in sulphuric acid, for this acid makes the tissue disappear entirely.

It may therefore be concluded that these membranes are formed exclusively by a single chief element, namely, *paraxylose*.

Chemical Characteristics of the Cellular Tissue of Roots.

This tissue is generally formed by the concentric superposition of the two substances which have already been cited, namely, pectose and xylose.

If, indeed, the cellular tissue of roots is treated with diluted potash, the pectose becomes dissolved and is transformed into alkaline pectate, whilst xylose remains unattacked.

The action of ammoniacal-copper reagent produces, on the contrary, the solution of the xylose and the transformation of pectose into gelatinous pectate of copper preserving the form of the cells.

The xylose of these tissues becomes altered very easily. It is dissolved in diluted mineral acids, and, as we have just seen, in copper liquor.

FIBRES.

Anatomical Characteristics of Fibres.

Fibres differ from cells only by their elongated form. Their length is variable. The junction of the fibres forms a tissue which is called *prosenchyma*. The section of this tissue shows in general a compact mass, in which the proportion of the solid part exceeds considerably the voids.

The development of the fibres is the same as that of the cells. The growth of the primitive utricle or of the exterior membrane determines their dimensions both in length and breadth. The most backward formation of the exterior layers determines their thickness and the

definitive appearance of their surface, which can consequently present the same modifications as that of the cells.

The existence of cracked and dotted fibres (Fig. 9) is very frequent.

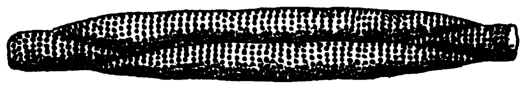

FIG. 9.

The cortical and ligneous fibres differ from one another by the following chemical characteristics:—

CHEMICAL CHARACTERISTICS OF CORTICAL FIBRES.

Cortical fibres, rid of fatty and resinous matters, may be considered as formed exclusively by pure fibrose. Concentrated sulphuric acid dissolves them easily without colouring them. Insoluble in potash, nitric acid, and the alkaline hypochlorites, they are immediately attacked by ammoniacal-copper reagent.

CHEMICAL CHARACTERISTICS OF LIGNEOUS FIBRES.

Ligneous fibres, whose constitution approaches greatly that of the medullary rays, are formed by two different principal elements. A substance can be extracted from them which is insoluble in sulphuric acid—*exofibrose*—and also a soluble substance, fibrose.

Submitted to the action of highly concentrated potash, nitric acid, and alkaline hypochlorites, these fibres leave insoluble fibrine, whilst exofibrose enters completely into solution.

The relative proportions of fibrose and exofibrose vary according to the age and variety of the wood.

DUCTS AND SPIRAL VESSELS.

ANATOMICAL CHARACTERISTICS OF THE DUCTS.

The ducts are considerably longer than the fibres; they often reach the total length of the plant which they constitute.

The following are the constant characteristics of the ducts:—

(1) The surface is never glossy, like that of cells or fibres.

(2) The duct has the form of a cylinder, which is not completely regular; narrowings or strangulations are observed in certain places. Like the utricles and fibres, the ducts are covered by points, lines, and bands forming a continuous spiral, either detached in links or joined together in a network.

Anatomical Characteristics of Spiral Vessels.

Spiral vessels are formed of a membranous cylinder, in the interior of which a spiral thread is rolled up. This cylinder, which is often very long, terminates by tapering like a cone at both extremities.

Fig. 10.

Upon these extremities other spiral vessels, which prolong the first, are as a general rule fastened (Fig. 10). The colour of the thread is usually of a nacreous white.

Anatomical Characteristics of Annular and Reticulated Ducts.

A membranous tube, supported in the interior by rings placed above one another, forms the constitutive part of the annular ducts. Generally

Fig. 11.

Fig. 12.

Fig. 13.

larger than the spiral vessels, they are also less uniform; neither are the rings of the same tube necessarily alike (Fig. 11). As a rule, they are horizontal, but they may also be inclined irregularly (Fig. 12). The same duct, annular in one part, may become reticulated in another (Fig. 13).

Anatomical Characteristics of Streaky Ducts.

These ducts are formed by transverse strokes, occupying only a portion of the circumference of the tube, and generally arranged regularly upon each other (Fig. 14). The duct often assumes the shape of a prism, whose lateral surfaces are grooved by lines, which discontinue towards the angles. These lines and their interstices present a ladder-like appearance.

ANATOMICAL CHARACTERISTICS OF DOTTED DUCTS.

The interior canal of these ducts can often be perceived with the naked eye; it appears as if studded by small specks, disposed upon either horizontal or oblique lines (Fig. 15).

Upon the surface of these cylindrical ducts, circles devoid of dots are delineated; these circles often form strangulations on the duct.


FIG. 14.


FIG. 15.

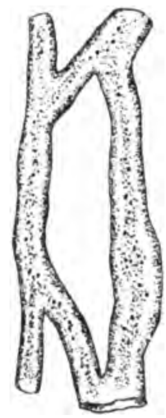
FIG. 16.

ANATOMICAL CHARACTERISTICS OF LATICIFEROUS VESSELS.

The sap (or *latex*) is enclosed in these vessels, which are membranous tubes communicating freely between themselves by transverse branches (Fig. 16), in such a manner that the whole forms a vast network.

CHEMICAL CHARACTERISTICS OF DUCTS AND SPIRAL VESSELS.

The composition of these organs resembles that of fibres and ligneous cells. At their outset these organs are exclusively formed by vasculose, insoluble in sulphuric acid, though soluble in nitric acid and in the hypochlorites. Later on, cellulose layers become joined to the membranes of vasculose.

CHAPTER III.

DIFFERENT PARTS OF WOOD, ANATOMICALLY AND CHEMICALLY CONSIDERED.

DIRECT ANALYSIS OF THE DIFFERENT PARTS OF A PLANT.

ANATOMICAL CHARACTERISTICS OF THE TRUNK OF DICOTYLEDONOUS TREES —PITH—WOOD—MEDULLARY RAYS—BARK—LIBER.

IN proportion as germination operates, the cells begin to form into fibres. They also become ducts, multiplying and grouping themselves together in several bundles, which are formed regularly like a circle (Fig. 17).

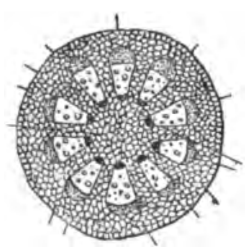

FIG. 17.

This first circle encloses a central one, which is completely cellular and is the pith, and is itself surrounded by an exterior zone of cells which will form the bark.

The bundles formed by the spiral vessels are separated from one another by bands of cellular tissue, causing the tissue of the pith to communicate with that of the bark; these bands are the first *medullary rays.*

The trunk soon presents itself as formed, from within outwards, by the parenchyma of the pith, the fibro-vascular circle, the cortical parenchyma, and, last, the cuticle.

A maple-tree branch a year old presents the disposition shown in Fig. 18. An horizontal cutting of this trunk shows that the spiral vessels and the fibres which are situated near the central pith form, along with the neighbouring ducts, a circle interrupted by the medullary rays, which has received the collective name of *medullary sheath.* The fibres situated outside of the sheath are called *ligneous fibres.* The more exterior fibres, separated from the preceding ones by a cellular zone and analogous to those of the medullary sheath, have received the name of

cortical fibres, or *liber*; and the cellulose zone, which separates the cortical from the ligneous fibres, is called the *cambium*.

The part lying outside the cambium constitutes the bark. The cortical pith *pc* is doubled on the exterior by a bed of cells *s*, serrated in the form of cubes or tables, of a whitish or brownish colour, and distinguishing themselves clearly from the cells of the cortical pith, which are polyhedral, coloured by green granules, and separated by numerous passages. This coating, more exterior than the cortical pith, has received the name of *suber* (cork), because in certain trees it develops considerably, and then forms the substance known under the name of cork.

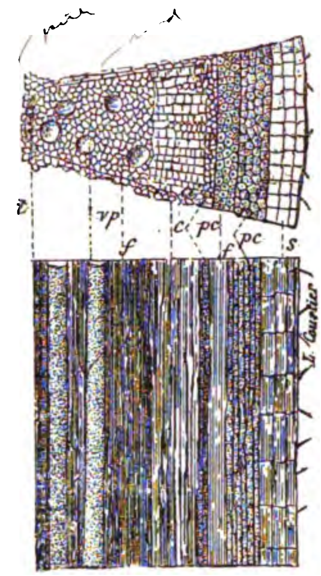

FIG. 18.

The second year the cambium forms new organs. The gelatinous tissue which constituted it and which represented a circular zone between the wood and bark undergoes the following changes:—Outside of the ligneous fibres and the large ducts which become intermingled there, 1 *vp* (Fig. 19), a new layer is formed, having the same composition, 2 *vpf*. Inside of the fibres of the *liber* and of the cortical pith a fresh layer quite similar is also formed. These cells are moulded upon the old ones, and the zone of the *cambium c*, which is transformed in order to produce them in all the points at which it was in contact,

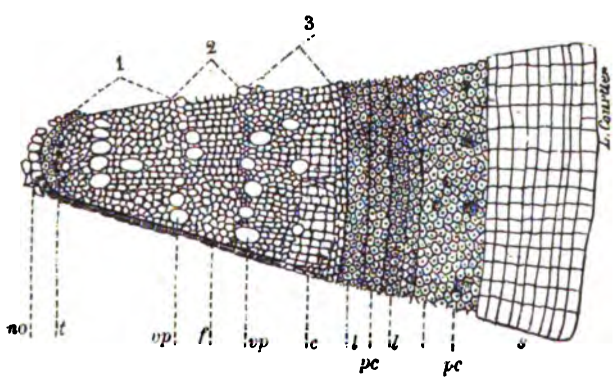

FIG. 19.

with layers of the same nature, preserves its cellulose organisation in the portion which corresponds to the cells of the medullary rays, so that these continue uninterruptedly from the central pith *no* to the

cortical bed *pc l*. Each primitive bundle was in this manner converted by a layer of cambium into two partial bundles, one belonging to the wood and the other to the bark. A similar bundle joins each of these partial bundles, as a result of the transformation of the cambium, and between the two newly-formed bundles another layer of cambium exists which the third year (3) will produce inside ligneous fibres and large vessels *vp*, whilst outside liber and cortical pith, and so on each year.

PITH.

Parenchyma, of which pith was exclusively formed, is later on found separated by the development of the ligneous circle into two regions, of which one (the central) is called *pith*: it is composed of cells which, from centre to circumference, diminish in volume, and at the same time they assume a greenish colour, which becomes darker and darker. These are gorged with copious juices, which, on the contrary, are missing in those of the centre, and from these different characteristics it can be easily recognised that they have a much more energetic life when they are younger. By degrees this energy gets feeble, and after the first year the pith usually loses colour and becomes white.

The cells, the size of which diminishes from the inside to the outside, contain nothing but air, and life appears to be in suspense there. They even often break, and air-cells, more or less considerable, are formed in the centre.

The diameter of the pith may also vary. By the multiplication of the cells and by the augmentation of each the pith becomes widened, and later on, when the ligneous bundles in their turn develop, they may in the same way extend in every direction, and by their extension inside compress the pith a little.

WOOD.

The first layer of wood is therefore composed of fibro-vascular bundles, arranged in a circle around the pith. They are separated from one another by rather broad bands of cellular tissue, stretched like rays from the pith to the bark. Later on fresh rays are developed in the thickness of these rays, and increase in number at the expense of their breadth. Finally, these bundles, by their multiplication and the augmentation of their total volume, end by drawing themselves together, and almost by touching each other, reducing the rays, which they separate, to very thin gills. They thus form a ligneous circle.

The ligneous circle, in its internal part, which has received the name of *medullary sheath*, presents a special structure. The pith becomes moulded upon this sheath, and the re-entering angles which it always presents at first, and which persist in certain trunks, correspond to as many projecting angles, which form the interior extremity of each of the bundles. The medullary sheaf is that portion of the wood which undergoes the least change. Its spiral vessels preserve the volume that they acquired at an early stage, and they may even show themselves in rather old trunks. The whole of the remainder of the ligneous circle is composed of fibres and vessels of another order—annular, striped, or dotted—generally of greater diameter. In ligneous plants, each year, between the wood and the bark (the interstice of which is filled by cambium), a layer of wood is formed, moulded upon the preceding one (Fig. 20). It is therefore at once seen that the number of layers represents the number of years that the tree has lived.

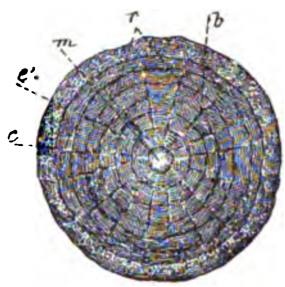

FIG. 20.

Let us take, for example, a log of oak or elm, and, after having cleanly cut a certain portion of the surface of the edge, if its zones are examined it will be seen that the interior side of each is delineated by one or several lines of small orifices, which are wanting in the remainder of the zone. These are the apertures of as many large vessels which are only found towards this interior side, whilst the layer outside is formed of compact fibres, thick enough to appear to be solid, so that the canal which runs through them lengthways escapes the naked eye.

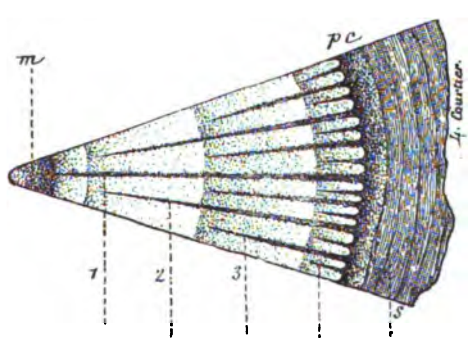

FIG. 21.

The number of the ligneous clusters increases, because new ones are developed from them in the cellular interstices, at first wide, which

separates them and which has served as origin of the medullary rays. These clusters are multiplied later on in another manner, which may be called inverse, since it is now the new medullary rays which interpose between the ligneous elements. The new bundle, however, thus applied over the old one, does not merely resemble it; it is double or triple, thus being divided into several sections by cellular rows, which commence fresh rays, 2, 3, 4 (Fig. 21), differing from the rays 1, in so far that they do not start from the centre *m*. In the new zone, which is larger than those which have preceded it (as it is exterior and concentric to them), it is naturally formed of a larger number of bundles and interposed rays.

The growth of each zone finishes in the course of the year; extended to a certain limit, it ceases there, and thus lays a settled base upon which the zone of the following year will rest.

As the plant gets older, the proportion of the liquids contained in the cavities diminishes relatively to the solids. As it is age which brings about these modifications, they should be more advanced in the most interior circles, the tissue of which is more copious, more solid, and drier.

In coloured wood the heart will first show the colour, and the coloration will proceed like the hardness of the wood, towards the circumference. It is from this cause that there is a difference in many trees between two parts of the wood:—

(1) The exterior one, which still preserves the qualities of young wood—that is to say, which remains impregnated by liquid juices, to which it is permeable, and is consequently more tender, paler, whiter, which has been the cause of its receiving the name of *aubier* (sap-wood).

(2) The other, and interior wood, dried up, hardened, and coloured, which is commonly called the *cœur* (heart) or *bois parfait* (perfect wood).

MEDULLARY RAYS.

The medullary rays, which, existing since the origin of the trunk, continue uninterruptedly from the pith to the bark, have been called *large rays* (Fig. 22); those which only appear in following years, and have their point of parting in the layers which correspond to these years, have been called *small rays*. The latter even appear in wood in which the distinction of the layers is not manifest, thus indicating successive formations, which the homogeneity

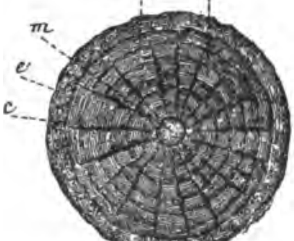

FIG. 22.

of the whole ligneous mass does not permit of being otherwise perceived.

It is towards the periphery of the wood, and consequently in the part where they find themselves in communication with the cortical system, that the rays are often of the greatest breadth.

BARK.

Bark, like the ligneous system, has a cellular and also a fibro-vascular portion; there is, however, inversion in the situation and in the relative proportion of the parts.

Parenchyma—a species of pith of the bark—occupies its periphery, and presents a greater development of the more changeable forms than the fibro-vascular bundles, whilst, on the other hand, in wood these bundles are much more developed and far less simple than pith.

Each year a layer of bark is formed at the same time as a layer of wood. The zones of wood remain motionless, but the new ligneous layer applying itself upon one older than that which it has just covered over, the zones of the bark are forced outside without cessation, to make room for other and younger ones, and especially for fresh ligneous layers, which are formed inside of them.

The epidermis is that part of the bark which must, by the resulting distension of the progressive growth of the trunk and by the action of exterior agents, be the first to disappear. Indeed, its existence is only temporary; and it finishes by bursting asunder, becoming dried up, and destroyed.

Under the epidermis other cellular layers are found:

(1) The *suberic layer*, thus termed, as we have already said, because in some trees it constitutes the substance known as *cork* (*suber*).

(2) The *cellular envelope*, also called *green layer*.

It is distinguished from the former by chlorophyl, which fills and colours green its polyhedral cells, whose walls are thicker, and leave between them passages or often gaps. In the middle of these green cells some are frequently found which contain crystallisations.

CORTICAL FIBRES, OR "LIBER."

These fibres form bundles placed opposite those of the wood, separated from them by a thin layer. Of a brilliant white, they are longer and more slender than ligneous fibres. Their coatings, in becoming older, get very thick; they are the most tenacious of all those of the plant, and consequently in a number of plants are of great service

to man, providing him with materials, cords, threads, and the most solid tissues.

The whole of the layers of several years (each of which can be subdivided into several others which are thinner) has been compared to a book of which all the different layers form the leaves; hence the name of *liber*, under which the cortical fibres are most ordinarily designated.

The layers produced in different years are, as are sometimes the yearly layers of the wood, separated by utricular zones, dependent from the cellular coat, in the thickness of which the fibrous bundles are formed.

The progressive growth of the stem determines the proportional distension of the layers of liber, whose vessels are separated from each other, and consequently grow broader. The rays, by the multiplication of the cells which compose them, become dilated in the same proportion as long as the tissue remains alive, and continue thus to fill them.

At the same time, a continual destruction of the exterior parts of the bark takes place, and this portion, driven outside and at last detached, may comprehend a greater or lesser thickness of the cortical layers, according as the development occurs in such or such of these coats, in such a way that it may be the suberic, cellular, or fibrous layer which may form the most exterior coating in which life is preserved.

ANATOMICAL CHARACTERISTICS OF THE TRUNK OF MONOCOTYLEDONOUS TREES.

In these plants, in proportion as the trunk is augmented and as, consequently, the bundles are multiplied in its interior, a disposition is observed which is different from that which they affect in the dicotyledons, where, ranged in a circle, they end by touching each other and forming a ligneous ring, cut only by lines and medullary rays.

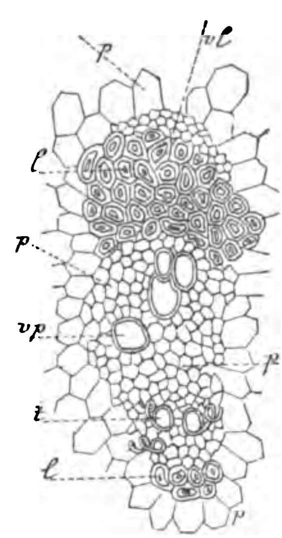

FIG. 23.

If the most developed part of a monocotyledonous tree is examined with the aid of the microscope, it is found, starting from the region concerning the centre of the trunk, that there are thick fibres analogous to those of the liber *l* and the spiral vessels *t*; then, in the middle, cells *p* (of which some enlarge and thicken into fibres) exhibit apertures of streaky or dotted vessels *vp*. The region of the bundle which makes up the circumference of the trunk

is formed of thick fibres (*l*) outside, and in the centre of these the laticiferous vessels branch out (Fig. 23).

If, however, the bundles, individually considered, do not differ from those of a trunk of a monocotyledonous tree a year old, their *ensemble* presents an important difference (Fig. 24).

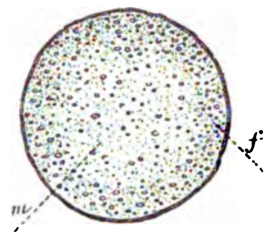

FIG. 24.

FIG. 25.

They are not grouped in a circular manner and disposed in concentric zones like those of the dicotyledons; each of them is an islet *f* separated from the neighbouring ones, not by the medullary rays, but by an irregular enclosure of pith *m*, where the bundles are dispersed and can be multiplied without being impeded by lateral pressure. Each of them is isolated and remains alone. At no period does it develop, between its cortical and ligneous systems, a bed of cambium destined to become organised and to form numerous bundles. The examination of the fibro-vascular bundles in a longitudinal slice of the ligneous stem of a monocotyledonous tree (Fig. 25) shows a difference which is much more pronounced between these two classes of plants. Each bundle, observed downwards, starting from the point of the stem whence it enters a leaf, descends at first obliquely towards the centre of the stem, afterwards vertically, then again obliquely towards the circumference; on the way it crosses successively all the older bundles situated below it.

Desfontaines has formulated in the following manner the great difference which exists between these two classes of plants:—

"According to the internal structure of stems, plants are divided into two great classes:

"(1) Those which have no distinct concentric layers, whose solidity decreases from the circumference towards the centre, where the pith is interposed between the fibrous bundles without medullary prolongations in divergent rays: these are the *monocotyledons*.

"(2) Those having distinct concentric layers whose solidity decreases from the centre towards the circumference, where the pith is enclosed in a longitudinal canal with medullary prolongations in divergent rays: these are the *dicotyledons*."

Anatomical Characteristics of the Trunk of Acotyledonous Trees.

For a long time it was thought that the interior structure of these stems was similar to that of the monocotyledonous ones. But a transverse cut of the stem of an arborescent fern (Fig. 26) shows fibro-vascular bundles *f v* of variable form, representing a circle more or less regular, which surrounds a yellowish central disc *m*, and is itself enclosed by a zone of the same colour *p*. This disc and zone are of the cellular tissue, and communicate conjointly by interstices more or less large, which separate the bundles. The entirely exterior blackish zone *c′* is a coating which has followed the epidermis, and which is formed by the bases of the leaves of branches, upon which, in a transverse cut, an organisation can be observed which is analogous to that of the principal stem.

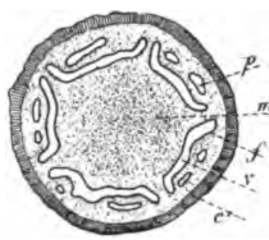

Fig. 26.

Chemical Characteristics of the Trunks of Dicotyledonous, Monocotyledonous, and Acotyledonous Trees—Epidermis—Suberose and Cortical Cells—Cortical and Ligneous Fibres—Medullary Rays—Spiral Vessels and Ducts—Parenchyma of Pith.

If an immediate analysis of a stem is desired, the epidermis, suberic cells, cortical cells, cortical fibres, ligneous fibres, medullary rays, the spiral vessels, ducts, and parenchyma of the pith must be at once isolated separately. The mechanical operations which allow of these separations being made are as a rule simple.

EPIDERMIS.

In stems, the epidermis encloses principally a waxy, fatty matter, and in addition epidermic cells containing different albuminous and colouring matters.

The analysis is commenced by drying the epidermis, and this is then submitted to the action of ether, which completely dissolves the fatty matter.

A treatment, slightly alkaline, then acid, effects the solution of the albuminous substances; the pectose becomes transformed into pectates.

The preceding reagents have completely eliminated the colouring substances. The cuticle and the membranes of the epidermic cells alone remain in an insoluble state.

Finally, concentrated potash dissolves the cuticle, and the cellulose

matter becomes isolated. Cellulose, however, dissolves if treated with sulphuric acid or by ammoniacal-copper reagent.

SUBERIC CELLS.

Colouring matters, as well as the fatty bodies, are at once carried off by neutral solvents.

The utricular tissue of the suberic cells is formed of suberin and paraxylose. If treated rapidly with nitric acid, paraxylose is not changed, but suberin is transformed into fatty acid, soluble in alkalies or ether. One can therefore carry off in this manner the derivatives of suberin and obtain paraxylose, which sulphuric acid will easily dissolve without coloration.

A solution of boiling and highly concentrated potash will dissolve suberin and leave paraxylose unattacked.

CORTICAL CELLS.

Paraxylose forms the base of these membranes, which comprehend utricles containing chlorophyll, fatty bodies, pectose, and nitrogenised matters. They are analysed by being successively acted upon by ether, alkalies, and acids.

CORTICAL FIBRES.

Almost completely formed by xylose, which the ammoniacal-copper reagent at once dissolves.

LIGNEOUS FIBRES—MEDULLARY RAYS—SPIRAL VESSELS.

Exteriorly, these organs are formed by exofibrose, exomedullose, and vasculose; in the interior they enclose cellulose substances. The cellulose bodies are first isolated from the epiangiotic bodies by concentrated sulphuric acid, which dissolves paraxylose.

If the other acids are used first, paraxylose is isolated, which afterwards dissolves in the ammoniacal-copper reagent.

PARENCHYMA OF THE PITH.

The analysis is commenced by purifying a tissue by means of neutral solvents, acids, and diluted alkalies, and this is followed by complete solution in the ammoniacal-copper reagent.

We will conclude at this point these anatomical and chemical considerations of the different parts of trees which are generally made use of; to continue them and deal with roots, leaves, flowers, and fruits would be to stray from our subject.

CHAPTER IV.

GENERAL PROPERTIES OF WOOD.

As has already been seen, wood is formed essentially by an *organic tissue* and by a small proportion of inorganic matter. As a rule, wood contains a great quantity of water, which can be carried off at rather a low temperature, always lower than that at which the organic matter becomes decomposed.

In every description of wood the elementary composition of the organic tissue is the same, but the latter is found associated with very variable organic elements, according to the species of the tree.

Pine-trees, for example, contain turpentine and oak-trees tannin.

The combustible part of wood is this same organic tissue.

The exterior characteristics of woods are very different from one another. Thus certain wood is soft, tender, and of a loose tissue, whilst another, on the other hand, is hard, tough, and of a compact grain. Thence there is quite a natural division into two classes. The first includes tender and soft woods, amongst which may be mentioned the fir, lime, etc. The second includes heavy and hard woods—for example, the oak, horn-beam, etc.

Amount of Water in Wood.

The quantity of water which wood contains is greatest at the time of the shooting of the sap, and smallest when vegetation ceases. Trees must therefore always be felled during the latter period, unless special circumstances compel one to act otherwise.

The researches of Schubler and Neufser have shown that the fir-tree (*Pinus abies*) contains in January 53 per cent. of water, and in April 61 per cent.; the ash-tree (*Fraxinus excelsior*) contains in January 29 per cent. of water, and in April 39 per cent.

Water is found in larger quantity in small branches and boughs than in the trunks of trees.

Schubler and Hartig have shown that the quantities of water contained in freshly-cut wood vary according to the variety.

These chemists have compiled the following table:—

	Per cent. of Water.
Horn-beam	18·6
Willow	26·0
Maple	27·0
Service-tree	28·3
Ash	28·7
Birch (*Betula alba*)	30·8
Beam-tree	32·3
English oak (*Quercus robur*)	34·7
Oak (*Quercus pedunculata*)	35·4
Fir-tree	37·1
Horse-chestnut tree	38·2
Pine-tree (*Pinus sylvestris*)	39·7
Beech-tree	39·7
Alder-tree	41·6
Aspen	43·7
Elm (*Ulmis campestris*)	44·5
Red fir-tree	45·2
Lime-tree	47·1
Italian poplar	48·2
Larch-tree	48·6
White poplar	50·6
Black poplar	51·8

According to M. Le Play, wood at the time of felling contains a quantity of water seldom below 45 per cent.

In the forests of Central Europe, wood cut during winter retains to the end of summer more than 40 per cent. of water. This proportion is often reduced to 33 per cent., when it is employed in manufactories and in domestic economy. Finally, wood preserved for several years in a dry place retains from 15 to 20 per cent. of water.

When wood has been completely dried and afterwards exposed to air in ordinary circumstances, it takes about 5 per cent. water during the first three years, then it continues to absorb it until it contains about 15 per cent. of it. It then becomes very hygrometrical, and loses or absorbs water according to the state of dryness or humidity of the surrounding air.

The proportion of hygroscopic water contained in wood can be calculated by weighing it at temperatures varying between 100° and 150° C.

The proportion of water carried off by desiccation has been determined by Violette, who found the following results:—

Temperature of the Desiccation.	Water expelled from 100 Parts of Wood.			
	Oak.	Ash.	Elm.	Walnut.
125°	15·26	14·78	15·32	15·55
150°	17·93	16·19	17·02	17·43
175°	32·13	21·22	36·94	21·00
200°	35·80	27·51	33·38	41·77
250°	44·31	33·38	40·56	36·56

We must observe that these figures are not to be relied upon, the decomposition of the wood commences before the extreme limits which this operator reached.

Af Uhr proved that the desiccation of wood in the open air is hastened by the removal of the bark. A certain number of trees were felled at the same time during the month of June, after the sap had risen. These trees were dried under cover during the four months which followed the felling of them; they were then cut into pieces of different lengths and diameters, some were stripped of their bark, whilst others preserved it integrally.

Af Uhr found the following results:—

	Loss per cent. of the Original Weight of Wood.			
	July.	August.	September.	October.
Trunks without bark	34·53	38·77	39·34	39·62
Trunks with bark	0·41	0·84	0·92	0·98

This shows the importance of stripping the bark in drying timber.

Density of Wood.

The density of wood, like that of all porous bodies, can be considered in two different ways, and can be looked for under its apparent volume. The only method which can then be employed consists in forming a prism with the wood, the volume of which can be easily measured, and then taking the weight of it. The ratio of this weight to that of the same volume of water would be the density sought for. This density for the same wood varies according to its hygrometrical condition and to the form and position of the fibres in the chosen sample.

The specific gravity of each species of wood is also found to be closely connected with the difference of structure, and also depends upon the solid matter which constitutes the cells, as likewise upon the water and the air which they contain.

In ordinary conditions, the following table gives the specific gravity of a certain number of woods:—

Pomegranate-tree	1·35
Guaiacum, ebony	1·33
Box-tree of Holland	1·32
Green ebony	1·21
Black ebony	1·18
Core of an oak sixty years old	1·17
Strawberry-tree	1·03
Rosewood	1·03
Medlar-tree	0·94
Olive-tree	0·94
English oak	0·93
Green walnut-tree	0·92
French boxwood	0·91
Spanish mulberry-tree	0·89
Canadian oak	0·87
Teak	0·86
Beech	0·85
Spanish mahogany	0·85
Trunk of ash-tree	0·84
Green acacia	0·82
Alder-tree	0·80
Spanish yew-tree	0·80
Apple-tree	0·79
Dutch yew-tree	0·78
Plum-tree	0·78
Maple-tree	0·75
Cherry-tree	0·75
Mahogany of St. Domingo	0·75
Horn-beam, with 20 per cent. water	0·75
Northern pine	0·73
Acacia, with 20 per cent. water	0·71
Birch-tree	0·72
Orange-tree	0·70
Wild quince-tree	0·70
Brown walnut-tree	0·68
Mountain ash	0·67
Trunk of elm	0·67
French walnut-tree	0·67
Pear-tree	0·68
Red pine	0·65
Beech-tree (after having been cut for one year)	0·65

Spanish cypress-tree	0·64
Maple-tree	0·64
Larch	0·64
Plane-tree	0·64
Oak	0·61
Lime	0·60
Hazel-tree	0·60
Sycomore	0·59
Willow	0·58
Cypress	0·57
Thuja	0·56
Mahogany of Honduras	0·56
Male fir-tree	0·55
White pine-tree	0·55
Elm	0·55
Larch-tree	0·54
Female fir-tree	0·49
Cedar of Lebanon	0·48
Willow	0·48
Poplar	0·38
White poplar of Spain	0·32
Cork-tree	0·24
Elder-tree pith	0·07

It is interesting to know the weight of the cubic metre of the different kinds of wood commonly on the market.

In Paris, ordinary firewood weighs, on an average, 350 kilogs. the stère. The faggots being 1 metre 14 cms. in length, the measure used in timber yards to deliver the stère is 1 metre long by 88 cms. high.

According to Berthier, the weight of the cubic metre of different kinds of wood is given by the following table:—

	Kilogs.
Oak forest in the neighbourhood of Moulins	275
Oak of the Monadier Forest, cut three years ago and quartered	386
Oak of the Monadier Forest, quartered	485
Oak of the neighbourhood of Cahors, cut a year ago	525
Beech of the neighbourhood of Moulins, quartered in large logs	400
Beech of the neighbourhood of Moulins, partly worm-eaten	375
Birch of the neighbourhood of Moulins, in large logs	440
Coal-mine aspen	190–220
Fir-tree of Moulins, in large logs	300–340
Elm	320
Yoke-elm	398

On the other hand, the researches of M. Chevandier de Valdrôme have led him to the following results:—

	Weight of a Stère of Dry Wood. Kilogs.
Oak with sessile acorns (quartered timber)	380
Beech (quartered timber)	380
Oak, two mixed varieties (quartered timber)	371
Yoke-elm (quartered timber)	370
Oak with pedunculated acorns (quartered timber)	359
Birch (quartered timber)	338
Yoke-elm (quarters and mixed logs)	361
Birch ,, ,, ,,	332
Fir (logs with sprigs)	312
Oak, the two varieties (logs with sprigs)	317
Beech (logs with sprigs)	314
Alder (quartered wood)	293
Alder (quarters and mixed logs)	291
Yoke-elm (logs with sprigs)	313
Beech (logs with branches)	304
Fir (logs with branches)	287
Alder (logs with sprigs)	283
Pine ,, ,,	283
Pine (logs with branches)	281
Yoke-elm (logs with branches)	298
Fir (quartered wood)	277
Willow (logs with sprigs)	276
Aspen (quarters and mixed logs)	273
Oaks, the two varieties (logs with branches)	277
Pine (quartered wood)	256

It may also be proposed to determine the density of the ligneous fibre of which wood is formed. M. Violette, who made a great number of experiments upon this subject, has employed the following method:—

The wood, reduced to fine powder by means of a rasp, is dried at 100°, then placed in a small bottle full of water, from which the air is exhausted, and in this the wood is left for six days.

By indicating, by P the weight of the flagon full of water before the introduction of the wood, by P′ the weight of the flagon equally full of water at the end of the operation, by π the weight of the wood introduced, and finally by δ the specific gravity of the wood, we obtain—

$$P' = P + \pi - \frac{\pi}{\delta} \text{ whence } \delta = \frac{\pi}{\pi + P - P'}.$$

M. Violette, following this method, found that all wood had the same specific gravity, and that it was equal to 1·50. For iron-wood, oak, wood of black alder, and poplar, the extreme variations are included between 1·51 and 1·52.

Chemical Composition of Wood.

The composition of wood, with reference to the elementary principles, greatly resembles that of the cellulose bodies, already dealt with. It is necessary to add to the constituent principles of cellulose—namely, carbon, hydrogen, oxygen—the principles of the sap, the mineral matters borrowed from the soil by vegetation, matters which are re-found in the ashes of wood after its combustion, and nitrogen.

The following table will show at a glance the elementary composition of dry wood, according to the analysis of Peterson, Schoedler, and Heintz. The samples of wood analysed were taken from the trunk of each tree.

ELEMENTARY COMPOSITION OF DRY WOOD NOT INCLUDING THE ASH.

Description of Trees.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Oak (*Pedunculata*)	48·94	5·94	43·09	2·03
Oak	49·43	6·07	44·50	...
Beech	48·29	6·00	45·14	0·57
Red beech	48·18	6·28	45·54	...
White beech	48·53	6·30	45·17	...
Birch	48·89	6·19	43·93	0·99
Yoke-elm	48·08	6·12	44·93	0·87
Alder	49·20	6·22	44·59	0·68
Ash	49·35	6·07	44·56	...
Horse-chestnut	49·08	6·71	44·21	...
Black poplar	49·70	6·31	43·99	...
Lime	49·41	6·86	43·73	...
Wild pine (old wood)	49·87	6·09	43·41	0·63
Wild pine (young wood)	50·62	6·27	42·58	0·53
Pitch pine	49·95	6·41	43·65	...
Common fir	49·59	6·38	44·02	...
Larch	50·11	6·31	43·58	...
Apple-tree	48·90	6·23	44·83	...
Box-tree	49·37	6·52	44·11	...
Walnut-tree	49·11	6·44	44·44	...

On the other hand, M. Chevandier de Valdrôme made numerous analyses of wood, the results of which are given in the following table.

In each testing the sample was taken from the sawdust of wood from the top, centre, and bottom of the trunk.

COMPOSITION NOT INCLUDING THE ASH.

Description of Trees.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.
Beech (70 years old)	48·89	6·13	43·09	0·88
Beech (58 years old)	49·96	6·02	42·79	1·23
Beech (69 years old)	49·75	6·04	43·09	1·12
Beech (wood of branches)	50·49	6·11	42·64	0·76
Beech (sprigs)	49·62	6·12	43·58	0·67
Oak (120 years old)	50·97	6·02	41·96	1·05
Oak (branches)	51·01	6·00	41·72	1·26
Birch (60 years old)	50·59	6·21	42·16	1·03
Birch (branches)	50·79	6·29	41·48	1·44
Aspen (25 years old)	50·31	6·31	42·39	0·98
Willow (20 years old)	51·75	6·19	41·08	0·98

If the results obtained in the analysis of different parts of the same tree are now collected, the following table is obtained:—

Nature of the Combustible.		Carbon.	Hydrogen.	Oxygen and Nitrogen.	Ashes.
Leaves		45·015	6·971	40·910	7·118
Small branches	Bark	52·496	7·312	36·737	3·454
	Wood	48·359	6·605	44·730	0·304
Medium-sized branches	Bark	48·855	6·342	41·121	3·682
	Wood	49·902	6·607	43·356	0·134
Large branches	Bark	46·871	5·570	44·656	2·903
	Wood	48·003	6·472	45·170	0·354
Trunks	Bark	46·267	5·930	44·755	2·657
	Wood	48·925	6·460	44·319	0·296
Large roots	Bark	48·085	6·624	48·761	0·129
	Wood	49·324	6·280	44·108	0·231

Wood Ash.

When a sample of wood is burned, a residue is obtained, made up of fixed mineral substances forming the ashes. Leaves and bark usually yield more ashes than the branches.

This question has been the object of a great number of researches, the most important ones being carried out by Chevandier de Valdrôme. This *savant* obtained the following results:—

	Number of Incinerations.	Ash per cent.
Willow	17	2·00
Aspen	59	1·73
Oak	93	1·65
Yoke-elm	73	1·62
Alder-tree	26	1·38
Beech	93	1·06
Wild pine	28	1·04
Fir	46	1·02
Birch	89	0·85

The proportion of ashes is influenced by the nature of the soil. Inorganic matter may be inequally distributed in the wood of the trunk of the same tree.

As to the composition of the ashes, the results of analyses executed by Witting may be given as an example, Nos. 1, 2, and 3 referring to the ashes from birch, and Nos. 4 and 5 to those from beech.

No. 1 had grown in a soil rich in alumina, iron sesquioxide, and in silica.

No. 2 in a soil very rich in lime.

No. 3 in a soil providing, upon analysis, nearly 95 per cent. of matters insoluble in acids.

No. 4 in the same soil as No. 2.
No. 5 in the same soil as No. 3.

COMPOSITION OF THE ASHES OF WOOD.

	Birch.			Beech.	
	1	2	3	4	5
Potash	12·81	5·67	14·78	6·94	10·91
Soda	1·60	1·25	2·77	0·34	1·23
Lime	26·72	46·89	...	43·59	13·55
Magnesia	2·22	1·69	11·78	5·39	12·03
Alumina	1·38	0·42	...	...	0·05
Fe_2O_3	0·78	0·47	...	0·62	...
MnO	0·00	1·67	3·81	0·00	3·47
Silica	2·88	1·51	4·00	2·13	6·36
Carbonic acid	18·83	24·67	12·92	28·29	26·24
Phosphoric acid	8·13	4·22	16·65	7·54	5·64
Sulphuric acid	0·02	...	2·77	0·62	1·04
Chlorine	...	...	...	...	...
Insoluble residue	7·17	7·17	9·84	0·62	6·68
Water	19·84	2·40	4·67	3·66	10·71
Charcoal	0·62	0·46	0·49	...	2·08

Other analyses, carried out by Will (at Giessen), furnish the following figures:—

	1	2	3	4
Potash	15·80	2·79	0·93	15·24
Soda	2·76	15·99	14·59	7·27
Lime	60·35	30·36	33·99	25·85
Magnesia	11·28	19·76	20·00	24·50
Mn_3O_4	...	18·17	7·61	13·50
Phosphate of Fe_2O_3	1·84	5·10	2·28	6·18
Fe_2O_3	...	...	7·73	...
Phosphate of lime	3·99	...	...	...
Sulphate of lime	2·30	3·31	5·05	2·91
Chloride of sodium	0·21	1·48	2·52	0·92
Silica	1·46	3·04	5·27	3·60
Ashes per cent. of wood dried at 100°	...	0·143	0·190	0·322

No. 1 was a *Fagus sylvatica* from Switzerland.

Nos. 2 and 3 *Pinus sylvestris* of Giessen, grown near the manganese mines.

General Distribution of the Inorganic Elements in Trees.

Chlorine.—The ashes of trees belonging to the *Amentaceæ* group almost constantly yield less than 1 per cent. of chlorine, and often only traces. The ashes of the *Conifers* appear to contain a trifle more—from 1 to 2 per cent.

Sulphuric Acid.—The proportions are variable. Several trees furnish less than 1 per cent.; such are the *Populus alba* and *tremula*; others contain up to 4 per cent. of it, like the *Populus virginiana*. The *Pinus strobus* provides up to 10 per cent.

Phosphoric Acid.—In the ashes of the *Conifers* 3 to 6 per cent. of it is met with; the oak and the young elm furnish from 7 to 9 per cent., boxwood 11 per cent. The *arborescent Rosaceæ* only give 3 to 5 per cent.

Silicic Acid.—The *frutescent* and *arborescent Rosaceæ* contain only some hundredths. The conifers, vine, and boxwood contain from 6 to 12 per cent.; and the *Amentaceæ* are almost completely destitute of it.

Potash—Soda.—Potash is the only alkali in the *Amentaceæ*. Conifers contain up to 6 per cent. of potash. As a rule, the plants have a greater tendency to absorb potash than soda. But the *Amentaceæ*, and trees in general, are much poorer in alkalies than the greater portion of the herbaceous plants.

Calorific Power of Wood.

When a combustible contains oxygen and hydrogen in the same proportions as water, its calorific power can be determined by the amount of carbon which it contains. This is the case with wood.

All descriptions of wood having obviously the same chemical composition must, at the same degree of desiccation, produce by their complete combustion the same amount of heat. Berthier's experiments led him to this conclusion.

Welter contended that all combustibles evolved the same absolute quantity of heat when they are combined with the same amount of oxygen. Dulong's experiments, however, have not confirmed this rule.

Hence it is, for example, that an equal weight of carbon and hydrogen take, in order to become transformed into carbonic acid and water, quantities of oxygen the ratio of which is 1 to 3, whilst the heat produced is in the proportion of about 1 to 5.

Welter's rule therefore is not exact as regards combustibles which differ from each other, like carbon and hydrogen, but it may be considered sufficiently exact if it is desired to compare the calorific power of combustibles in the same physical state, or thereabouts, like wood and coal.

It is by building upon this rule that Berthier gave a method of determination of the calorific power—a method which is not rigorously exact, but which, however, we will point out later on, first, on account of its great simplicity, and, secondly, because it is still often employed in laboratories.

The calorific powers of wood depend upon its hygrometrical condition. Now, this state may vary in very extended limits; the calorific power of the wood to be tested can only be ascertained after having first determined the quantity of water which it contains.

If desiccation is to be obtained at 100°, it is sufficient to take a certain weight in the state of sawdust, to dry it in a capsule heated in a water-bath, and to weigh the wood when the disengagement of vapour is terminated. In applying this method, however, a certain quantity of water retained by the ligneous fibre is still left.

The simplest method is to employ an ordinary lamp. The warm air coming out of the chimney is about 300°, and the current of air preserving this temperature diminishes as it rises. If, consequently, a vertical cylinder, open at both ends, were placed in the current of warm air, the average temperature of the air which would go through it would not be so high as if the cylinder were placed at a greater altitude. But in order to apply this disposition to the treatment of wood, it would be necessary for the currents of warm air which traverse the cylinder to be mingled so as to take an even temperature.

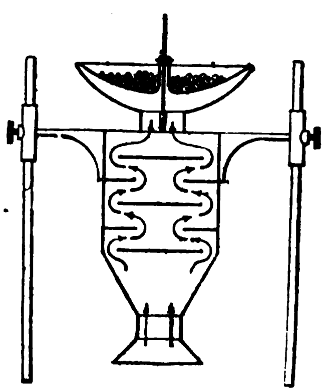

FIG. 27.

An apparatus has been pointed out by Péclet which satisfies these conditions (Fig. 27).

The cylinder is in sheet-iron; it is about 0·10 m. both in diameter and height. It is divided inside by several diaphragms, which force the current to pass successively, sometimes to the circumference, sometimes to the centre. This cylinder is terminated at the lower part by two stems of cone placed in an inverse direction. At the top it is furnished with a concave surface and with a sheet-iron capsule, carrying a tubule, through which the stem of a thermometer is passed. The apparatus is supported by two supports, which allow of its being placed at a convenient height.

BERTHIER'S METHOD OF TREATMENT, OR BY LITHARGE.

In accordance with what has already been said, it will be perceived that, without knowing the composition of a combustible, its calorific power can be determined if the weight of oxygen which it requires for complete combustion could be estimated.

Several metallic oxides are reduced so easily that, upon heating them with a combustible body like wood, the latter gets burnt integrally without any of its elements being able to escape the action of oxygen. The composition of the oxide is known; if, therefore, the weight of the part which has been reduced be taken, the proportion of oxygen having participated in the combustion can be deducted from it.

Experience has proved that litharge can be employed very advantageously. The following is the mode of procedure:—

An intimate mixture of from 30 to 40 grms. of litharge with 1 grm. of wood to be treated is introduced in an earthenware crucible; the mixture is covered with 20 to 30 grms. of litharge. The whole is placed in an already-warmed stove, and progressively carried to red-heat. The mixture softens, boils, and swells. When fusion is complete the heating is continued for about ten minutes, in order that all the lead can be got together in a single homogeneous and well-melted mass.

The crucible is withdrawn from the furnace, then broken after complete cooling. The lead is easily withdrawn, carefully cleaned, and weighed.

In the operation the combustible part of the body submitted to the treatment becomes completely transformed into water and carbonic acid under the influence of the oxygen of the lead oxide. If Welter's rule is applied, the weight of the lead obtained is exactly proportional to the quantity of oxygen which the wood has taken to burn and consequently to its calorific power.

It is always necessary to operate with pure litharge. Pure carbon would produce, from litharge free from minium, 34 times its weight of lead, and hydrogen 103·5 times its weight—that is to say, a little more than three times as much as the carbon.

If the wood contains volatile matters, the proportion of them is known by the immediate analysis; if, moreover, the proportion of lead which it gives with litharge is sought for, it is easy to calculate the equivalent in carbon of the volatile matters, and, in consequence, to know what is the calorific value of the substances which are extracted from wood in submitting it to carbonisation.

Let us suppose, for example, that the sample treated furnishes after distillation a quantity A of charcoal, subtraction made from the weight of the ashes, and a quantity B of volatile matters, that it produces a weight M of lead.

The quantity A of charcoal would give 34A of lead; the quantity B of volatile matters would only give $M - 34A$; it would therefore be equivalent to $\frac{M - 34A}{34}$ of carbon. It therefore follows that the quantities of heat developed by the charcoal, the volatile matters, and the non-changeable combustible would be between them like the figures 34A, $M - 34A$ and M, which represent the quantities of lead, or like the figures A, $\frac{M - 34A}{34}$, and $\frac{34}{M}$, which represent the quantities of carbon.

Knowing, therefore, the proportion of lead which the testing of a wood gives with litharge, its calorific power can be easily calculated, for direct experiments have determined the weight of pure water which the charcoal can heat by 1°; this weight is, according to Despretz, equal to 7·815 times that of charcoal. Now, as this body produces with litharge 34 times its weight of lead, it follows that each part of lead produced is equivalent to 230 calorific units or calories.

The analysis of any wood considered as a combustible is generally made in the following manner:—

(1) The proportion of water at 120° in the drying-stove is determined.

(2) In order to fix the quantity of combustible volatile parts, 1 or 2 grms. of wood are put into a closed platinum crucible, which is rapidly brought to red-heat. As soon as the volatile parts cease to burn above the lid, it is allowed to cool and is weighed.

(3) Afterwards the ashes and the carbon of the coke left by the first calcination are determined. For that, the crucible is heated to red-heat without covering it until all the carbon is burnt. The new weight gives the amount of ash; the carbon is estimated by difference.

(4) Finally, the ashes are examined and analysed.

MM. Scheurer Kestner and Meunier submitted cellulose to combustion in Favre and Silbermann's calorimeter. These experimentalists found that this substance gives almost exactly the quantity of heat corresponding to that of the carbon which it contains. They found as calorific power the value 3·622, and as cellulose contains 44·44 of carbon, that the calorific power of the pure carbon is 8·080, the product $8·080 \times 0·4444$ gives 3·591—a value approximating 3·622.

As wood dried at 140° contains on an average 0·50 of carbon and, besides, 0·01 of free hydrogen, its calorific power would be—

$$0·50 \times 8080 + 0·01 \times 34462 = 4384 \text{ calories};$$

but this is on the supposition that the product of combustion has been completely condensed, which does not ordinarily take place. If account of this is taken in the calculation, the average value of 4·000 heat units is arrived at.

It may be admitted *en résumé*:

(1) That all wood at the same state of desiccation obviously produces the same quantity of heat.

(2) That for wood thoroughly dried artificially, the calorific power is about 4·000 calories, deduction being made of the latent heat of the water which remains in the products of combustion.

(3) That for wood in the ordinary state of desiccation, which includes about 25 to 30 per cent. of water, the calorific power varies between 2·600 and 2·800 calories.

In order to terminate what is relative to the calorific power of wood, we give the table of experiments of Berthier and Winckler, indicating, for certain species of wood, the quantities of lead reduced and the quantities of water vapourised per kilogramme of each wood.

Nature of Wood.	Lead reduced per kilogramme of Wood. Kilogs.	Water evaporated at 100° per kilog. of Wood. Kilogs.
Oak	12·50	5·27
Ash	14·96	5·97
Sycomore	13·10	5·53
Beech	13·70	5·77
Fir	14·50	6·11
Pine	13·70	5·77
Horn-beam	12·50	5·27
Elm	14·50	6·12
Poplar	13·04	5·50
Lime	14·48	5·11

PART II.

DESCRIPTION OF THE DIFFERENT SPECIES OF WOOD.

CHAPTER V.

PRINCIPAL VARIETIES WITH CADUCOUS LEAVES

FURZE (*Ulex Europæus*) (Fig. 28).

THIS shrub is also known under the name of *Jonc marin* (marine shrub); it is usually found in the sandy waste lands of Western France, of Brittany, and of Normandy.

FIG. 28.

Its wood is yellowish white, hard and heavy, and is extensively used in the heating of furnaces.

SERVICE-TREE (*Cratægus*) (Fig. 29).

White or Common Service-Tree (*Cratægus aria*).

This tree may reach a height of about 33 ft.; its trunk often has a

circumference exceeding 3 ft., though upon mountains this is never more than a shrub. Its wood is very hard, of a fine and compact grain, a very fine polish often being acquired. It is often used in the making of tool-handles and flutes, and its charcoal is highly valued.

FIG. 29.

FIG. 30.

FIG. 31.

Service-Tree of the Woods (*Cratægus terminalis*) (Fig. 30).

This can also grow to a height of more than 33 ft. Its wood is white, compact, of a fine grain, and thoroughly preserves the colour which is given to it. It is greatly sought after by joiners and carpenters; it is also of use to engravers, and likewise makes a good firewood.

Service-Tree of Fontainebleau (*Cratægus latifolia*).

This differs from the preceding by its angular leaves, which are much larger. Its wood serves the same uses.

SEA BUCKTHORN (*Hippophë rhamnoïdes*) (Fig. 31).

This is a shrub which flourishes in the damp sands of downs and in

calcareous earth. Its wood, of a hard, yellowish-brown nature, is not of use as a combustible, but it is very rich in potash.

ALDER-TREE (*Alnus*).

The alders are trees with simple, alternate leaves. They belong to the *Amentaceæ* family. A dozen different varieties are known, the principal being:

Common Alder (*Alnus glutinosa*) (Fig. 32).

This tree may attain a height of about 70 ft. The leaves are rounded and dentated on the edges. This is the most aquatic tree in Europe, growing very well in marshy lands, where neither the poplar nor the willow can exist. Alders are generally planted in those portions of forests where the soil is most watery, around meadows and pasture-grounds. If the subsoil contains any iron mineral—limonite, for instance—its vegetation is arrested.

The greatest longevity of the alder is about sixty years. The stumps of alders give, after their trunk has been cut, a large number of sprouts, which, after the end of the first year, grow to five or six stalks. These young alders are ready, after seven or eight years, to be made into poles, which are sold to turners.

FIG. 32.

In copses, alders may be cut every seven years, and then serve to make ladders, chairs, rough bedsteads, broom-handles, vine-props, hay-rakes, etc. Builders also employ alder-perches to support their scaffolding.

The wood of the trunk of these trees is employed in light timber-work; it is utilised for making water-conduits and piles, which last as long as those of oak, provided they be always in water or damp earth. It is of equal use in the making of wooden shoes and clogs. The grain of this wood is homogeneous, its pores being scarcely apparent, but it is soft, and the joiner does not ordinarily use it.

The combustion of the alder does not produce great heat, though it gives plenty of flame. It is largely employed by bakers and lime and plaster manufacturers.

Being very astringent, the bark of the alder can be utilised in the tannage of leathers.

In northern countries this species is replaced by the following:—

White Alder (*Alnus incana*) (Fig. 33).

This tree does not flourish so well as the preceding one in damp earth; it grows better in sandy soil. It finds the same uses as the foregoing.

BEZOAR (*Gymnocladus*).

The straight and naked trunk is terminated by a bushy and slightly spread summit. The average height is from 15 to 20 metres (about 50 ft. to 65 ft.). It is an exotic tree, the wood of which (very compact and rose-coloured) is very fine and strong. It has scarcely any sapwood, and can be employed in all kinds of cabinetmaking.

FIG. 33.

FIG. 34.

WHITE BIRCH-TREE (*Betula alba*) (Fig. 34).

The white or common birch is a tree the height of which may attain about 60 ft. and the stem a diameter of about 3 ft. It is distinguished over all the trees of the forest in so far as it succeeds in the most arid and the most humid soils. Its wood, tinted with red, presents a fine grain, can be easily polished, and it is fairly durable. Joiners, turners, cabinetmakers, and wooden-shoe makers often use it.

Birch wood is white and light; it burns rapidly with a very clear flame. Its charcoal is employed in the making of gunpowder.

In the north of Europe its bark replaces that of the oak for the tannage of hides. The Swedes utilise its sap in the preparation of a syrup which is substituted for sugar, and hence provides an agreeable alcoholic liquor.

Box-Tree (*Buxus sempervirens*).

This is a shrub whose stem may acquire a large diameter. The wood of it is of a palish-yellow colour, and its tissue is very close and compact. It is heavier than water.

Its wood, whilst being excellent as firewood, serves besides in the making of beads, whistles, buttons, taps, forks, spoons, combs, snuff-boxes, etc.; it is also extensively used by wood-engravers. Its leaves, after having served the purpose of litters for herds, produce a very good manure.

Wild Cherry-Tree (*Cerasus avium*) (Fig. 35).

The height of this tree does not exceed 10 to 15 metres (about 33 ft. to 50 ft.). Its bark (smooth, whitish, and a little red) is formed of several layers easily becoming separated.

The wood of this tree is stout, reddish, hard, and compact; being easily workable, it takes a beautiful polish. Turners, cabinetmakers, and joiners often employ it.

Fig. 35.

Fig. 36.

If it is steeped for several days in lime-water, it is made to acquire a beautiful brownish-red colour, which allows of its employment in cabinetmaking in place of mahogany. It is equally useful as carpenters' timber and as firewood. Its fruit, which is highly esteemed, serves by distillation in the fabrication of different liqueurs.

This species grows well in forests and in the shadow of large trees; the cherry-tree flourishes in mountainous countries, as well as in calcareous, light, and sandy earth.

CHERRY WOOD OF ST. LUCIA (*Cerasus mahalib*) (Fig. 36).

This a shrub growing easily in the worst ground, and even in the clefts of rocks. The wood, which is hard and odorous, is largely employed in the cabinetmaking industry.

HORN-BEAM.

COMMON HORN-BEAM, OR YOKE-ELM (*Carpinus betulus*) (Fig. 37).

This tree is not of very great interest. Its stem may reach the height of about 60 ft., and its trunk from about 4 ft. to 5 ft. in diameter. Growth is slow, and it produces less timber than the oak. Its wood is white, hard, heavy, and of a close grain, and it is necessary to wait until it is very dry before using it. Being less elastic than the ash, it renders yeoman service in wheelwrights' work, but it is especially useful as firewood, on account of its lighting easily and of its flame being very bright.

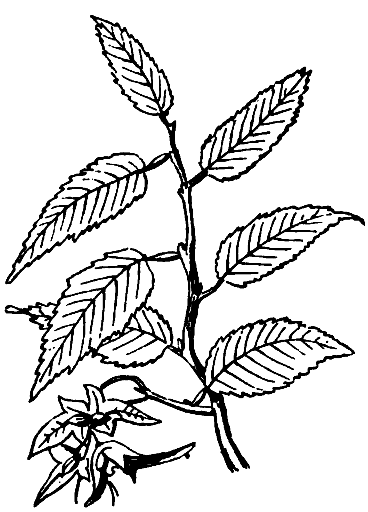

FIG. 37.

FIG. 38.

HOP YOKE-ELM (*Ostrya vulgaris*) (Fig. 38).

Very analogous to the preceding, this is found more generally in Italy and upon the borders of the Adriatic. Its wood, like that of common yoke-elm, is excellent for the fire-grate.

Common Chestnut-Tree (*Fagus castanea*) (Fig. 39).

This is one of the most precious trees, by virtue of its height, the quality of its wood, and the abundance and goodness of its fruits. It can be easily developed in sandy soils. Its timber is very analogous to that of the oak, but its colour is less developed, and contact with air does not make it so brown. Its durability is extreme; and it is of great service to carpenters and joiners. It can also be employed in the manufacture of casks and tubes for water-pipes.

Fig. 39.

It is little valued for firewood (for it does not give any flame), as it blackens and cracks in the fire.

It is well known what great services its fruit renders for the feeding of the poor classes, especially in the provinces of the south and in the centre of France.

American Chestnut-Tree (*Castanea vesca*).

This tree greatly resembles the chestnut-tree of Europe; it may reach a height of about 100 ft., with a diameter of about 6 ft. Its fruits are smaller and sweeter than those of Europe. Its wood is strong, elastic, and resistant, and can be of use in the making of stakes and barriers, which last well.

OAK.

INDIGENOUS OAKS WITH CADUCOUS LEAVES.

Oak with Sessile Acorns, or English Oak (*Quercus robur*) (Fig. 40).

The oak has certainly been for centuries the most important tree of the forest. The strength and excellence of its wood and the beauty of its foliage have always given it preference in the planting or renewing of forests. Oaks are divided into two classes: those having caducous leaves (which are lost in winter) and those with persistent leaves, or evergreen oaks,

The *rouvre* (or English) oak is a very high tree, generally with smooth bark in its infancy, but greyish and unequal when it gets old. The black oak of Fontainebleau is a variety of the English oak.

Fig. 40.

Fig. 41.

PEDUNCULATE OAK (*Quercus pedunculata*) (Fig. 41).

This grows higher and more quickly than the preceding one. Its leaves are wider at the top, and its fruits are carried by a longer peduncle.

This tree flourishes in argillaceous earth, whilst the English oak rather prefers fresh sandy soils. Forest-rangers call it *gravelin* or *chêne femelle* (female oak). Less knotty than that of the English oak, its wood splits more easily. It is preferred for laths, flooring, furniture, and carpentry in general.

Moreover, the wood of these two kinds is largely employed, and it occupies the first rank as building material.

The bark, especially that of the English oak, furnishes an excellent tan. The fruits, or acorns, serve as food for some animals.

PYRAMIDAL OAK.

This species resembles the English oak in its leaves, and the pedunculate oak in its fruits. Now very largely planted in the environs of Paris, it grows naturally in the Pyrenees and the Landes of Gascony.

Fibrous Oak (*Quercus cerris*) (Fig. 42).

This is a tree whose height may reach about 33 ft. The trunk is knotty and twisted. It is also known by the names of Burgundy oak and Austrian oak. Its wood is of use in building.

Fig. 42.

Fig. 43.

Tauzin or Angiers Oak (*Quercus tauza*) (Fig. 43).

This may attain a height of about 85 ft. The acorns are yielded by auxiliary peduncles. Its wood, which is hard and nutty, is highly esteemed for buildings and firewood.

Several varieties of it exist, such as:

(1) The tauzin with pedunculate, axillary, and terminal acorns, with slightly ciliated cup.

(2) The tauzin with pedunculate axillary acorns.

(3) The tauzin with small pedunculate, axillary, and terminal acorns growing in clusters.

INDIGENOUS OAKS WITH PERSISTENT LEAVES.

Evergreen Oak (*Quercus ilex*) (Fig. 44).

This is a tree with a small tortuous stem, having a large number o branches, which are oval and have rough bark. Its wood is susceptibl of taking a beautiful polish, but it cracks easily and deteriorates in drying It is used in the making of axle-trees, crow-bars, and beams. Its barl furnishes a tan of superior quality.

The heart-wood is very much sought after for mallet handles. As a rule, this tree grows well in dry and sandy soil.

FIG. 44.

FIG. 45.

CORK-OAK (*Quercus suber*) (Fig. 45).

This is a valuable tree, details of which will be given later. It is found in the provinces bordering the Mediterranean; its trunk often reaches an enormous size. The bark is very thick, cracked and spongy. The wood of the cork-oak makes an excellent firewood; it is also largely employed in joinery work.

EXOTIC OAKS.

WHITE OAK (*Quercus alba*).

Native of North America, it greatly resembles the oaks of Europe. It receives its name from its bark, which is very white but is spotted with black. The wood is of a reddish colour, and is useful for a number of purposes, and especially in the construction of ships. Being very strong and elastic, it lasts very well; it is, however, not so weighty and compact as the oak of Europe, and is but little used in carpentry.

AQUATIC OAK (*Quercus aquatica*).

This is widely spread in Virginia, the lower portion of Carolina, and in Eastern Florida; it occupies the narrow marshes, and its height does not exceed about 50 ft. Its wood is very hard, though not so supple or elastic as that of the white oak.

SCARLET OAK (*Quercus coccinea*).

This is a beautiful tree, abounding in Pennsylvania, Virginia, and in the upper portion of the Carolines. It may grow to a height of about 100 ft.; it receives its name from the nature of its foliage, which, in autumn, is of a magnificent scarlet colour. An excellent tan is produced from its bark.

WHITE OAK OF THE MARSHES.

The leaves of this tree are, underneath, of a beautiful silver-white colour, whilst on top they are of a brilliant green.

OAK WITH LYRE-SHAPED LEAVES (*Quercus lyrata*).

This is met with in America, upon the banks of the Mississippi, and in Eastern Florida. The wood is inferior to that of the white oak.

OAK CHESTNUT-TREE (*Quercus montana*).

This tree abounds on the banks of the Hudson and upon the hills that are met with near the Alleghany Mountains. At the height of about 60 ft. it presents a beautiful patulous head, and may thrive very well in the environs of Paris. Its wood is, after that of the white oak, the most sought after for the building of boats; it is also excellent as firewood.

"POST" OAK (*Quercus obtusiloba*).

This is an excellent tree, the wood of which is very hard. It is only of medium height, but it grows very well in dry and poor earth.

RED OAK (*Quercus rubra*).

Both a cold climate and a fertile soil are essential to the development of this oak. Its wood is rough and of mediocre quality, but its bark is largely employed in the tannage of leather.

QUERCITRON OAK (*Quercus tinctoria*).

Very fine specimens of this oak are met with in the United States on both sides of the Alleghany Mountains. Its wood, which is of a reddish colour and having a rough grain, is largely employed in the making

of staves, and furnishes an excellent combustible. The bark is very rich in tannin, but it gives to leather a peculiar yellow colour. The cellular portion of this bark furnishes quercitron, a dye-stuff which dyes wool, silk, and wall paper yellow.

EVERGREEN OAK (*Quercus virens*).

Seaside air appears to be necessary for the existence of this tree, which is but rarely met with inland. Its wood is very heavy, compact, and of a fine and close grain; it is also much more durable than that of the white oak, and is largely employed in naval constructions. It also provides a tannin of the first quality.

VELANI OAK.

This oak grows principally in Greece and in the Archipelego Islands. It has the aspect of French oaks, but its leaves have on their edge angular lobes; they are coriaceous, smooth, and slightly pubescent. The fruit is very large; the cupule, which is voluminous, contains a great quantity of astringent elements. In the East and in Greece it is often substituted for the gall-nut.

DOG-BERRY-TREE OF FORESTS (*Cornus mas*) (Fig. 46).

This is a large shrub growing naturally in woods and copses, on calcareous soil. It grows very slowly, and it may reach a very advanced age. Montmorency Forest contains one of them to which the remarkable age of a thousand years is attributed. The middle of the old dog-berry-tree is brown and its sapwood white. Its wood is very hard, its fineness making it susceptible of acquiring a beautiful polish. It is used for making spokes of wheels, ladders, quoins, and pins. The bark of the branches, which is very astringent, can be used as febrifuge.

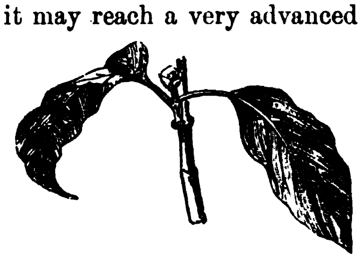

FIG. 46.

BLOOD-COLOURED DOG-BERRY-TREE (*Cornus sanguinea*).

The branches of this shrub are of a brownish-red colour; it grows spontaneously in the woods and copses of the south of Europe, where it forms very bushy hedge-rows. Fagots for firewood are made with the stems and branches.

Hazel-Tree (*Corylus avellana*) (Fig. 47).

This is also called "nut-tree," and its wood resembles that of the yoke-elm, but it will not burn easily. When it arrives at a certain age, it is used in the making of hoops and hurdles.

False Ebony Cytisus (*Citisus laburnum*).

This is a tree of moderate height, the papilionaceous flowers of which are arranged in long, yellow clusters. It grows amongst mountainous woods in almost every country of Central Europe.

The wood of this tree is very hard, supple, elastic, and is very durable; it gets blackish with age and will take a beautiful polish, which is the cause of its being employed by cabinetmakers and turners.

Fig. 47.

Fig. 48.

MAPLE-TREE.

The maple-trees constitute a genus having numerous species and varieties and being largely distributed throughout Europe. They generally have a straight stem, with opposite leaves, polygamous flowers, and flattened and winged fruits.

Sycamore Maple, or Plane-Tree (*Acer pseudo platanus*).

This is the most remarkable variety, and is of the largest size. Its roots are both tap-rooted and running. The stem can reach about

100 ft. high and about 3 ft. in diameter; it is straight, regular, and cylindrical, and is covered with a greyish-brown bark, generally smooth and becoming cracked and knotty in very old trees.

Several varieties of this tree are known, one especially, which is variegated with white, yellow, and red, and is exquisite as an ornamental tree.

The sycamore maple (Fig. 48) is found in the mountainous regions of Central France, Germany, and Switzerland. It flourishes better in mild climates, though it also prospers in the high regions of the Alps.

This tree vegetates in almost every description of soil, though it flourishes best in fresh soil, well worked, permeable, and of a dark colour.

The sycamore maple-tree has a rapid growth. In a good soil it will often attain, at the age of seventy years, a height of about 80 ft.; and it may live for more than two centuries.

As the sycamore maple alone rarely forms groups of any importance, it is little used for plantations. It can be used towards its hundredth year, and the same treatment as is accorded to beech applied to it; in fact it is often used with this wood. Rather strong specimens of it are advantageously employed in joinery, cooperage-work, and cabinetmaking.

The sycamore is largely employed to border paths; the lopping off of its branches is easy, and is done as in the case of the ash. It is sometimes cultivated as a pollard, and if care be taken in the cutting of the lateral branches at about 50 cms. from the stem, wood is obtained which is more veiny, more streaked, and more sought after for marquetry and veneering.

The wood of this tree is white, with a slight yellowish or ashy tint; agreeably veined, elastic, firm without being very hard, of a dense tissue, and of a fine grain capable of being beautifully polished. It can be easily worked, and is employed in carpentry provided it is sheltered from atmospheric variations. It is not subject to warping, and worms rarely attack it.

This wood is in great demand for cabinetmaking, joinery, lathes, wheelwrights' work, and cooperage It is also used in the manufacture of musical instruments, stocks of guns, and for wood flooring. Bows, pestles, rollers, various vessels, tables, etc., are made from it.

The roots and excrescences, which are better veined, are especially in demand for marquetry.

The maple is rarely employed for firewood or in the making of charcoal; this is on account of its high price, which reserves it for the arts.

As a firewood it is superior to the majority of the other species; indeed, Hartig places it in the first rank in this respect. It must be added that the ashes are very rich in potash.

The sap of the sycamore maple, like almost all its congeners, contains a certain proportion of sugar; but its cultivation from this point of view is scarcely advantageous, and cannot compete with that of the other sacchariferous plants generally cultivated. In the regions of the North a fermented beverage is sometimes obtained. The leaves may serve as animal food, and the flowers are much sought after by bees.

PLATANE MAPLE (*Acer platanoïdes*) (Fig. 49).

This is also known by the name of "Norwegian maple." It differs from the preceding by its height (which is not so great), its yellowish bark, red buds, more pointedly-lobed leaves, yellow flowers, in dressed clusters, and its flattened and non-sloped fruits.

FIG. 49.

The wood is not quite as good for cabinetmaking as that of the sycamore. It is of a watery white, firm without being hard, is easily worked, and takes all colours. It is especially employed for musical instruments, tables, and chests.

Along with the sycamore, the maple is amongst the most beautiful trees employed for avenues, gardens, parks, etc.

This species of maple is still less subject than the sycamore to the attacks of insects.

SYLVAN MAPLE (*Acer campestre*) (Fig. 50).

Appreciably smaller than the two others, it grows to a height of about 40 ft. to 50 ft., or more.

It often assumes the form of a bushy shrub. Its suberic and cracked bark is of a fawn colour on the young branches. Its leaves are small, with rounded lobes.

The growth of this tree is very slow; but it may live for two centuries. It does not attain such a height upon mountains as the preceding ones, and is found in woods on dry and stony soils.

This species is the best, after the yoke-elm, to form hedges and palisades. The wood is hard, homogeneous, fine, of a dullish white, and will take a beautiful polish. Like that of other maples, it serves in the

FIG. 50.

making of lathes, joinery, cabinetmaking, and musical instrument-making. Poles, whip-handles, small furniture, and snuff-boxes are made from it. The wood is also very useful as firewood and for the making of charcoal.

MONTPELLIER MAPLE (*Acer Monspessulanum*).

This tree is of average size, the trunk of which is often very large. It has plenty of branches, and is of a beautiful form. Its bark is reddish; its leaves have three very regular lobes, and the fruit is very small (Fig. 51).

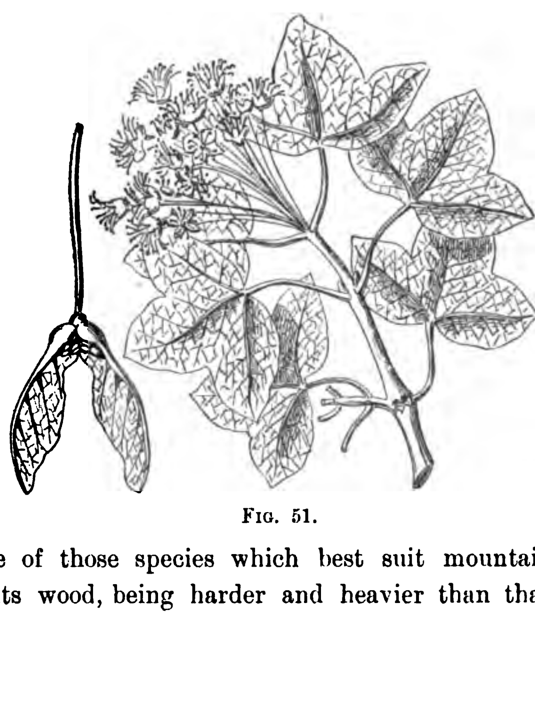

FIG. 51.

It is one of those species which best suit mountainous and arid countries. Its wood, being harder and heavier than that of the other

maples, is employed for the same purposes, though it is notably useful in cabinetmaking.

Several varieties of maples are found in North America, amongst which may be cited—the red or tomentose maples (*Acer rubrum*), the sugar-maple (*Acer saccharinum*), the jasperated maple (*Acer Pennsylvanicum*), the mountainous maple (*Acer spicatum*), and finally the " Negundo " or ash-leaf maple.

THREE-HORNED ACACIA (*Gleditzia*).

These are exotic trees, largely distributed in gardens; their wood is hard, supple, red-veined, and of a fine and compact grain.

ASH-TREES.

Ash - trees form a part of the *Jasmineæ* family, and are mostly large, pinnate-leaved trees. There are about forty species of ash-trees, the largest of which grow in America. The following are the principal:—

TALL OR COMMON ASH (*Fraxinus excelsior*) (Fig. 52).

This tree, when full grown, may attain a height of about 100 ft. The branches are smooth and of an ashy-green colour; the leaves are large, opposite, and formed by oval or oblong folioles. The ash grows naturally in forests, and preferably in light and moist soil. Its growth is rather slow. Before the discovery of quinine its bark was used as a febrifuge.

The wood of the ash is white, longitudinally veined, rather hard, supple, and very elastic. It is largely employed industrially, being notably used in wheelwrights' work for the manufacture of those pieces which require plenty of elasticity, such as carriage shafts. It is also equally useful in the making of ladders, chairs, tool-handles, and the hoops of casks.

Magnificent furniture of a yellowish tint is produced with this wood by the cabinetmaking trade; it is also useful as firewood and provides a good charcoal.

The other principal European varieties are:

The **Silver Ash,** the *gravelly ash*, the *jasperated-wood ash*, the *gilt ash*, the *horizontal ash*, the *umbelliferous* or *weeping ash*, the *ragged-leaf oak*, and the *white-streaked leaf ash.*

Amongst the exotic varieties may be cited:

The **American Ash,** or white ash, which is the most remarkable for the quality of its wood. This tree is principally found in Canada and Tennessee.

The **Caroline Ash** — a species limited to the United States; it grows rapidly, but does not exceed a height of 33 ft.

The **Blue Ash,** an excellent tree, thus named because a beautiful blue colour can be extracted from its bark.

The **Black Ash**: its bark is dull, and its wood (which is largely employed) yields ashes which are very alkaline and highly charged with potash.

Fig. 52.

The **Red Ash**—a species which is very common in Pennsylvania, Maryland, and Virginia. Its wood is of a bright red colour, possessing many good qualities, though it is not so elastic as the foregoing.

The **Green Ash** is of very small dimensions and, consequently, is not employed largely.

Prickwood (*Euonymus*).

The prickwood of Europe (or *priest's cap*) is a small tree, whose wood, of a yellowish-white colour, is very light, and has a fine and compact grain. Sometimes employed in marquetry, it is most often used in making distaffs and larding pins.

Reduced into charcoal, it can be used in the making of powder for heavy artillery. The charcoal made from young branches is used by draughtsmen.

Beech-Tree (*Fagus sylvatica*) (Fig. 53).

This is one of the most beautiful trees of the forest, often growing to a height of about 70 ft. A large and full top usually crowns it.

Beech wood is very liable to contraction upon being dried. Being slightly elastic and only of medium strength, it is employed but little by carpenters; it is, however, extensively used in marine constructions, and boats can be made from one single trunk of it. This wood is preferable of all others for the making of oars, and it also provides excellent shafts for post-chaises and wheel-fellies.

It is constantly employed in both the cabinetmaking and joinery trades; it makes a good firewood, though it burns rather quickly. Its fruit—the beech-nut—produces an excellent oil, which is likewise good

Fig. 53.

Fig. 54.

for edible purposes. The beech-tree flourishes in almost all kinds of soil, provided they are neither damp nor marshy.

Fig. 55.

HOLLY-TREE (*Ilex aquifolium*) (Fig. 54).

Though often very small, yet it may sometimes attain a height of about 33 ft.

The wood of this variety is hard, solid, and heavy; its grain, which

is fine and compact, permits of its taking a black colour easily. It is extensively employed in cabinetmaking, and beautiful furniture can be manufactured from this variety; it is also useful in making tool-handles, wheel-teeth, brake-wheels, flail-handles, and for certain lathe work.

The leaves possess very marked properties as a febrifuge.

CHESTNUT-TREE (*Esculus*) (Fig. 55).

The horse-chestnut-tree is very beautiful, but of little utility; its wood is soft and valueless. Battens and packing-boards are generally made from it. The fruit, reduced to flour, serves to make a rather good paste, and contains a rather large quantity of potash.

NETTLE-TREE (*Celtis Australis*) (Fig. 56).

The nettle-tree of Provence is also found in Italy. The stem, which may reach a height of about 70 ft., is smooth and of a greyish colour when the tree is young; later on it becomes blackish and knotty.

FIG. 56.

The wood of the nettle-tree is compact, flexible, and very supple, and may be employed in a variety of ways. It grows in almost every soil, though principally in those that are light and fresh.

WALNUT-TREE.

This is a very useful species, and includes the following varieties:—

BITTER-FRUIT WALNUT-TREE (*Juglans amara*).

In America this tree grows to immense dimensions; specimens about 5 ft. in diameter are not unfrequently met with. The fruit of

this tree is sharp and bitter; an excellent lubricating oil is extracted from it. The wood is very strong, tenacious, and elastic.

Common Walnut-Tree (*Juglans regia*).

The fruit of this tree is, on the other hand, largely employed as a foodstuff. Its wood is in great demand by turners and cabinetmakers, furniture being made with it.

Fig. 57.

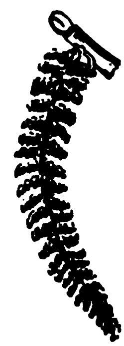

Fig. 58.

Fig. 59.

Figs. 57, 58, and 59 represent the fruit, the male flower, and the female flower of this tree.

Aquatic Walnut-Tree (*Juglans aquatica*).

This variety always grows in marshes and ditches; its wood is of inferior quality.

Butter Walnut-Tree (*Juglans cathartica*).

Equally of very large dimensions, this tree has roots which extend, on the surface of the earth, to very long distances. The trunk branches out to a slight height, and forms a broad, bushy head. The nuts are hard, and rounded at the base; the kernel is thick and oily.

The wood is light, of medium strength, and possessing a reddish tint. Its bark is very purgative.

BLACK WALNUT-TREE (*Juglans nigra*).

Very largely distributed in France, this tree flourishes in deep, fertile, fresh, though not too damp soils. In America it is one of the most beautiful trees known; the bark is hard, whilst the kernel, of an agreeable and sweet taste, is inferior to the European nut.

The middle of the wood of this tree changes, upon exposure to the air, from a violet to a blackish tint. Being very strong, tenacious, not liable to warp, and susceptible of receiving a beautiful polish, this wood could remain in the earth for thirty years without becoming rotten. It is useful for a variety of purposes, and it is one of the most valuable species known.

SQUAMOUS WALNUT-TREE (*Juglans squamosa*).

This variety grows to an immense height, with a small diameter. Its bark is disposed in squamous gills; and the form of the stem renders it very suitable to the making of masts of vessels.

Its wood is very strong, elastic, and tenacious.

FIG. 60.

FIG. 61.

WILD OLIVE-TREE (*Olea Europæa*) (Fig. 60).

This is found in Southern Europe; it is a species of hard, compact, and heavy wood.

The olive-tree is largely employed for sculpture, wood-engraving, marquetry, and the lathe.

ELM.

Common Elm (*Ulmus campestris*) (Fig. 61).

The wood of this tree is yellow, marbled with brown shades, hard, heavy, and capable of acquiring a beautiful polish. It is preferably used in the making of naves and fellies of wheels, cross-bars and axle-trees of carriages.

With the exception of the oak, it is the best building wood.

Twisted Elm (*Ulmus minos*) (Fig. 62).

This is a variety of the preceding, and one of the most valuable trees.

Fig. 62.

Fig. 63.

Pedunculated Elm (*Ulmus pedunculata*) (Fig. 63).

This is a native of Russia, but it has become very common along the French highways. The flowers are pedunculated, and its fruit ciliated upon the edges. The liber of this elm is useful in the making of coarse rope, and its leaves are employed for forage.

POPLAR.

Poplars belong to the *Amentaceæ* family. Twenty varieties of these large trees are known, amongst which six belong to Europe, whilst the others form part of the forests of North America.

WHITE POPLAR (*Populus alba*) (Fig. 64).

The leaves of this tree are longer than they are broad, denticulated unequally, glabrous, and of a deep green colour on top, clothed underneath with a whitish down.

The wood of this tree is light, white, soft, and flexible.

FIG. 64.

FIG. 65.

GREYISH POPLAR (*Populus canescens*) (Fig. 65).

The leaves of this species are smaller, and the inferior down is rather greyish than white.

This tree is especially found in fresh and damp soil.

FIG. 66.

FIG. 67.

ASPEN POPLAR (*Populus tremulus*) (Fig. 66).

The leaves are heart-shaped, finely denticulated, and as pubescent as the branches which carry them.

BLACK POPLAR (*Populus nigra*) (Fig. 67).

This tree may attain a height exceeding 100 ft. The leaves are almost triangular, crenated upon their edges, glabrous, and of a bright green colour. This variety grows equally well in humid soil and upon river-banks.

ITALIAN POPLAR (*Populus fastigiata*) (Fig. 68).

The trunk of this tree is always very straight; its branches and boughs, serrated against the stem, form long pyramids. It may attain a height of about 125 ft.

FIG. 68.

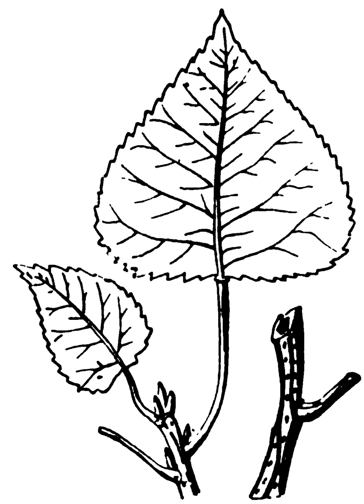

FIG. 69.

CANADIAN POPLAR (*Populus Canadensis*) (Fig. 69).

The leaves are large, of heart-shape, glabrous, denticulated round thei edges. Of Canadian origin, this tree is extensively found in Europe.

VIRGINIA POPLAR (*Populus monilifera*) (Fig. 70).

Like the preceding ones, this tree may attain a good height. Th leaves are not so large and the female husks of the nut are longer tha in any of the preceding varieties.

In general, the wood of the poplar is but little employed in build ings; wooden shoes are made from it; and carpenters saw it into boar for the making of cupboards, doors, and tables. In Paris this wood i largely employed by cabinetmakers for the body of furniture veneered i mahogany.

The common branches of all these trees serve, in country places, as firewood for furnaces and fire-grates.

FIG. 70.

PLANE-TREES.

This is a large species of trees belonging to the *Amentaceæ* family; they have alternate leaves, cut into lobes, more or less deep. Two principal varieties are known, as follow:—

ORIENTAL PLANE (*Platanus orientalis*).

This is a very ancient variety, being even known by the Romans.

WESTERN PLANE (*Platanus occidentalis*, or *acerifolia*) (Fig. 71).

Like the foregoing, this tree may attain a height of about 100 ft., and even more; its trunk often acquires colossal greatness; it does not suffer so much from the effects of the cold as the Oriental platane, and it also becomes more easily accustomed to climate in France.

A fatty soil, slightly humid, and of a good depth, is necessary for plane-trees; they attain the largest dimensions in the vicinity of rivers.

The most frequent use made of plane-trees is in the making of avenues.

The wood of the plane-tree is of a beautiful serrated tissue, resembling that of the beech-tree. Like the latter, it is of a clear, reddish colour; it is speckled with small spots of a dark colour. It is easily split, and worms attack it. But if the precaution be taken to cut

it up into pieces, and submerge them afterwards in water for some time, these inconveniences are easily averted. This wood is adapted for wheelwrights' and joiners' work. The lower and thicker parts of the trunk

Fig. 71.

are especially serviceable in making furniture; cut into boards, they frequently show beautiful veins and marblings.

As firewood, the platanes produce, in burning, a bright flame, and give plenty of heat. The ashes are rich in potash.

Pear-Tree (*Pyrus communis*) (Fig. 72).

As is generally known, the qualities of pear-tree wood are very excellent. A great amount of it is used in wood-engraving, carpentry, lathe-work, and especially cabinetmaking.

False Acacia Robinia (*Robinia pseudoacacia*) (Fig. 73).

This tree belongs to the *Leguminosæ* family, and is more generally known under the name of "acacia." It is one of the most beautiful species known, its height reaching about 100 ft., whilst its trunk is often about 5 ft. in diameter.

The flowers, which appear in June, are white, and of an agreeable odour, being disposed in beautiful hanging clusters.

The robinia grows far more rapidly than all the hard timbers with which it could be compared.

In spite, however, of its rapid growth, its wood is very hard and

heavy; it is yellow, with rather darker veins; it has a fine, serrated grain, can be easily planed, and is capable of taking a beautiful polish, which makes it figure prominently in cabinetmaking. This wood is also very useful for turnery.

In the United States it is often employed in naval constructions.

FIG. 72.

FIG. 73.

Resisting as it does putrefaction very well, it is equally useful for making stakes and palisade-enclosures which last for a number of years. Pile-work is often made of it. It is likewise an excellent firewood.

The bark of the stems and branches is purgative.

WILLOWS.

There are more than a hundred varieties of willows. They form part of the large *Amentaceæ* family. They are either trees or bushes having alternate leaves, the flowers of which are all masculine, or all feminine upon different species.

WHITE WILLOW (*Salix alba*) (Fig. 74).

The height of this tree may reach about 33 ft. or 50 ft.; it grows in all kinds of soil, though preferably in those which are light, fresh, and damp.

Its wood is white, tender, and light, and serves the same purposes as that of the poplar, whilst being preferable to it.

Osier Willow (*Salix vitellina*) (Fig. 75).

This variety differs from the foregoing by its branches, which are of a deep yellow colour, and by its leaves, which are more narrow and glabrous. As osier, it is used for basket-work and bands.

Fig. 74.

Fig. 75.

Fragile Willow (*Salix fragilis*).

This tree greatly resembles the white willow; its boughs offer little resistance, and are very brittle. It is principally this variety which is planted with the white willow on the borders of meadows and pasture-lands.

The wood of the white, as likewise of the fragile, willow is reddish or ruddy; it has a rather fine and smooth grain; it works well whether with the jointing-plane or lathe. Wooden shoes are principally made with it. It is rarely employed by joiners, unless for common work.

The bark of these trees is bitter and astringent; and in certain countries it is utilised in the tannage of leather.

Babylonian or Weeping Willow (*Salix Babylonica*).

The horizontal branches of this tree, divided into long slender boughs, give to it quite a particular aspect. The leaves are narrow, lanceolated, glabrous, and of a tender green colour.

Marcescent Willow (*Salix caprea*) (Fig. 76).

This tree may attain a height of about 50 ft. Its greyish branches are furnished with oval or rounded leaves. It is common in the fresh and damp forests of France, growing very quickly.

The wood which is obtained from this tree is very suitable for making vine-props, hoops, laths, forks, poles, etc. Small fagots are made with the slender sprigs, which are very useful in country places in the heating of furnaces and grates, as likewise in the burning of bricks, lime, and plaster.

This wood produces a clear flame, though of practically no duration and heat. Of a reddish-white colour, it has a fine and serrated grain, and is easily worked up. Wooden shoes, planks for joinery, and carpenters' timber are produced from it.

The bark (which is bitter and astringent) has been employed in substitution of quinine.

FIG. 76.

FIG. 77.

OSIER-LIKE WILLOW, OR WHITE OSIER (*Salix viminalis*) (Fig. 77).

Of short growth, this willow has very narrow, thin branches, clothed when young with a silky down, presenting linear, lanceolated, and slightly undulated leaves, green and glabrous on top, coated underneath with a silvery down.

This species, common in France, provides excellent bands and first-class material for basket-work.

PURPLE WILLOW, OR RED OSIER (*Salix purpurea*) (Fig. 78).

This grows upon the banks of rivers in soils of sandy alluvium, and greatly resembles the preceding variety, though its leaves are more narrow. Its branches being also very flexible, it is employed for the same purposes.

HELIX PURPLE WILLOW (*Salix helix*) (Fig. 79).

This last variety does not grow to a greater height than about 10 ft. Its branches are thin and glabrous, furnished with leaves which

FIG. 78.

FIG. 79.

are rarely alternate and lanceolate, being of a delicate green colour on top and glaucous underneath.

SORBS.

These trees belong to the *Rosaceæ* family. This genus includes four species, the two following of which are indigenous to France:—

MOUNTAIN ASH (*Sorbus aucuparia*) (Fig. 80).

The leaves of this species are large, winged, dentated, and slightly pubescent. The flowers are white, numerous, and slightly odorous, being disposed in a large cluster at the top of the branches. Birds are very fond of the fruit, whence its name in French (*Sorbier des oiseaux*).

The wood of the mountain ash is hard and whitish; its grain is fine and serrated; and it can be easily worked and well polished. It is in great demand by turners, and tool-handles are also made from it, but as it is not so common as the service-tree, the latter is preferred, the qualities of which are the same.

SERVICE-TREE, OR "CORMIER" (*Sorbus domestica*) (Fig. 81).

This tree may attain a height double that of the mountain ash. The leaves, formed of about fifteen oval and oblong folioles, are green on top, and velvety and whitish underneath. This tree grows naturally in France and in European forests.

FIG. 80.

FIG. 81.

Its wood is of a fawn or reddish colour, slightly veined, very hard and compact, and of great solidity. The grain, which is very fine and serrated, allows of its being given a beautiful polish. It is in great demand by armourers, cabinetmakers, joiners, mechanics, and turners.

Being highly esteemed for work which sustains great friction, it is principally useful in the making of teeth of wheels, as also those for mill-wheels, the mountings of planes and jointing-planes, screws of presses, etc.

It is often substituted for boxwood for engraving.

ELDER-TREE (*Sambucus*).

The *black elder* (*Sambucus nigra*) is the most interesting species. It is a large shrub belonging to the *Caprifoliaceæ* family, the leaves of which are opposite, pinnate, lanceolate, and of a rather deep green colour. The flowers are small, white, and very numerous.

The elder grows naturally in France and in a great part of Europe. It grows well in all kinds of soil, provided it be not too dry.

It is used rather commonly for making hedges, which grow rapidly.

The wood of the elder becomes rather hard with age, and good for

the lathe. It has the colour of boxwood, and is often substituted for it. Vine-props are made with four-year-old stems, the duration of which is rather great. In country places the branches of the elder are utilised as firewood.

LIMES.

These trees have given their name to the *Tiliaceæ* family. Their leaves are alternate, and the flowers disposed like a cluster. There are some ten species of lime-trees; the most interesting of which are:

Large-Leaved or Dutch Lime (Fig. 82).

This tree may grow to a height of about 65 ft. Its trunk, clothed in a thick, cracked bark, acquires a very large diameter with age. The leaves, which are round, rather heart-shaped at the base and dentated round the edges, are of a beautiful green colour. The wood of this species is white, rather light, slightly hard, but very supple, worms attacking it only with difficulty. Joiners employ it extensively, as do likewise bushel-makers and coopers. It is also largely used by sculptors and wooden-shoe makers. Young lime-trees serve to make perches and props.

Fig. 82.

The second bark, or *liber*, stripped from the young stems, is used for making cords, matting, bindings for sheafs, vines, etc.

Small-Leaf Lime (*Tilia microphylla*).

The leaves of this tree are half the size of those of the preceding. It is met with in France, Bohemia, and Russia.

Silver Lime.

This is distinguished by the white and serrated down which covers the lower part of the leaves. The flowers have an agreeable odour analogous to that of jonquil. It is found in the forests of Hungary and Turkey.

TULIP-TREE (*Lyriodendrum tulipifera*).

Both in North and South America this tree attains a height of from about 100 ft. to 125 ft., with a diameter of about 3 ft. at the base.

When this tree is young its bark is smooth and soft, afterwards becoming cracked and thickening. The centre of the matured wood is lemon-yellow in colour. Finer and more compact than that of the poplar, its wood can be worked well and given a beautiful polish.

JAPANESE VARNISH-TREE (*Aylanthus glandulosa*) (Fig. 83).

This large tree is a native of Japan, and was introduced into France towards the year 1750. It grows rapidly, acquires great hardness, and is easily propagated.

FIG. 83.

As a rule, it grows well in all kinds of soil, though it prefers a fresh and light one. Its wood is solid, somewhat brittle, and is used by the joinery trade. It provides a good firewood, giving a bright flame and providing charcoal analogous to that of the elm.

EUCALYPTUS.

The *Eucalyptus globulus*, of the *Myrtaceæ* family, is of Tasmanian origin, as well as of the eastern portion of the province of Victoria (Australia), where it is known by the designation of *blue gum-tree*. This species of tree was introduced into Algeria in 1857, since which time

plantations have been multiplied, and it is now found upon the whole of the littoral of the Mediterranean. It may grow to a height of about 325 ft., with a diameter of about 33 ft.

Its rapid growth, and the extraordinary development of the *Eucalyptus globulus*, make its cultivation very important. Generally, the wood of trees which grow rapidly is light and soft; it changes promptly under the influence of air and damp. It is not so, however, with the wood of the eucalyptus, which is heavy, hard, and very resistant to the action of air and water. Moreover, it is not liable to attack by insects.

The great usefulness of the wood of the eucalyptus arises from these diverse qualities; it presents the advantages of the wood of oak, and can even be substituted for "tawn" and teak wood. It is consequently largely employed in naval constructions.

The majority of the steamers which travel between Australia and Europe are constructed with this wood. The renowned soundness of the whalers of Hobart Town is due to the employment of this wood.

Eucalyptus plantations spread aromatic emanations through the atmosphere which are beneficial to the health; these emanations are due to an essential volatile oil, which is very abundant both in the leaves and in the bark.

Eucalyptus essence is oxygenated; it is formed primarily by *eucalyptol.* This product boils and distils at 170° C.; it is slightly soluble in water, though very soluble in alcohol.

Fatty and resinous bodies dissolve easily in eucalyptol, which makes it very useful in the manufacture of varnish.

The bark of the blue gum-tree contains both tannin and the aromatic principle of the leaves; employed in the preparation of leathers, it transmits to them a very agreeable characteristic odour, their preservation being thus ameliorated.

At the side of *Eucalyptus globulus,* another very useful species may be noticed, namely, *Eucalyptus gigantea.* This tree is likewise of very rapid growth; its wood is very resistant, being three times more so than that of the oak of Riga or Hungary.

This tree grows to a height of about 325 ft. in the worst mountainous soil of Victoria. Its wood, which is hard and very easy to split, is useful in cooperage work, as well as for the making of laths, and a sort of wooden tile for the covering of houses.

The usefulness and value of this tree consist especially in the abundance and quality of its fungo-fibrous bark, which serves as a very useful material in the manufacture of paper, bleaching very easily.

CHAPTER VI.

CONIFEROUS RESINOUS TREES.

In this manner are designated a family of ligneous plants, composed of large, medium, and small trees, divided into several species, the common characteristic of which is that they are resinous.

Almost all of them retain their leaves during winter, and for this reason they have been called *evergreen trees* or *trees with persistent leaves.*

The wood of these trees is used in civil and military architectural work, and it cannot be replaced by any other variety. One very great advantage which this family possesses is the simple growth of the trees which compose it. The poorest soils suffice for them; they even grow amongst rocks.

America and Northern Europe are the countries where the conifers are most abundant.

The most important varieties will now be noticed.

Cedar of Lebanon (*Cedrus Libani*).

This is the most celebrated and the most majestic of the conifers. It is met with on Mount Lebanon, and has never been found growing indigenously in any other part of the globe.

Formerly it was very abundant in France; by degrees it disappeared, though numerous plantations of it were made both in France and elsewhere.

It grows well in a siliceous soil, more dry than damp.

Without speaking of the cedar of the "Jardin des Plantes," several celebrated cedars are cited, amongst others that of the Château de Vrigny, the dimensions of which are about 175 ft. in height and 6½ ft. in diameter.

Common Cypress (*Cupressus sempervirens*).

This is a small pyramidal tree, a native of Greece. Its wood is

rather fine and more beautiful than that of the pine, but when it is worked with it spreads a very disagreeable odour.

COMMON JUNIPER-TREE (*Juniperus communis*) (Fig. 84).

This variety grows indigenously in France, but it is more often met in bad than in good soils.

As the common juniper-tree never gets very large, its timber is usually employed as firewood in country places.

FIG. 84.

In places where it grows into a small tree, it is made into clapboards, for the making of buckets and other vessels, which last a long time, because its wood is incorruptible and of a very fine grain.

EASTERN JUNIPER (*Juniperus excelsa*).

Differing from *J. communis*, this is a large pyramidal tree, native of the banks of the Caspian Sea. On account of its colour, density, and strength, its wood is very valuable.

VIRGINIAN JUNIPER (*Juniperus Virginia*).

This is commonly called *Red* or *Virginian Cedar*. The wood from it, which is of a reddish colour and odorous, is useful in the making of lead pencils.

YEW (*Taxus baccata*) (Fig. 85).

This tree is indigenous to the mountains of the south of Europe. Its growth is very slow, its height rarely exceeding about 33 ft.

When it grows wild, it assumes a pyramidal form; its leaves are very numerous, alternate, distic, linear, lanceolate, pointed, and of a very deep green colour.

The trunk of the yew has white sapwood, not very thick, the middle of which is of a beautiful orange-red colour, tinted, and very hard and heavy. Being of a fine grain, it is incorruptible and takes a beautiful polish. It is largely employed in marquetry and lathe-work and for veneering furniture. The crossing of its fibres renders it also very adaptable for carriage-work and for all those uses where pliancy and durability are essential.

FIG. 85.

LARCH-TREE (*Larix Europæa*) (Fig. 86).

This tree belongs to the flora of the Alps; it is acclimatised with difficulty elsewhere.

FIG. 86.

The wood of the larch provides an ordinary firewood; it is likewise very useful in the carpentry and joinery industries. Venetian pitch is produced from it, and a very good tan can be obtained from its bark.

THE PINE (*Pinus*).

This is the most useful, as likewise the most numerous, species of the coniferous family. The cold zones of the two hemispheres have immense

forests of it. Certain varieties reach a height of about 160 ft., others do not exceed about 16 ft. They all have filiform leaves.

The fruit, which is called the cone, varies in size according to the particular species.

Rosin or tar is produced, in larger or smaller quantity, from all the varieties of pine, and the wood (which is always very durable and adapted for building purposes) is the more esteemed because it comes from a variety of larger dimensions, and also on account of its having a finer grain and offering greater resistance to destructive agents.

Sylvester Pine (*Pinus sylvestris*) (Fig. 87).

This tree loses its qualities in proportion as it is removed from the latitudes comprised between 50° and 60°. On the other hand, in these latter regions it multiplies rapidly.

Fig. 87.

It is also found in the Alps, Pyrenees, Vosges, and the Auvergne Mountains.

In order that this pine should attain its full height (which exceeds about 100 ft.), it is necessary that it should grow in forests. Its stem then shoots up very straight, its bark remaining smooth and greyish. The ternate or quaternate branches then grow at increasing distances apart, and the wood of the trunk is better. The leaves are of a dark greyish-green colour, tough and very hard. The fruit is small, and shorter than the leaves.

This tree does not appear to be able to attain all its dimensions in the plains of the south of France. It prospers in the Alps and Pyrenees, on account of the altitude. Granitic mountains are very suited to its growth, and it is the situation of the North which is the most favourable to it.

Scotch Fir (*Pinus rubra*).

In Scotland large forests are formed of this tree. It also grows naturally in the Alps and Pyrenees. It is generally considered as a variety of the sylvester pine, and serves the same purposes.

ALEPPO PINE (*Pinus halepinsis*) (Fig. 88).

This tree bears few leaves, but is rather elegant; the leaves are long and fine and of a glaucous green colour, two or three in the same sheath. It grows in Provence, Syria, and Barbary.

KERNEL PINE (*Pinus pinea*) (Fig. 89).

The *pinier*, *pignon*, or *parasol* pine grows in Southern Europe, and is scarcely known in France. Its trunk is large, but the stem is hemi-

FIG. 88.

FIG. 89.

spherical and very wide. Its bark shows spiral striæ, which is an indication of the vigorous growth of the tree.

The leaves are longer and of a more beautiful green than those of the forest pine, and its cones, which are as large as the fist, contain kernels which are good to eat.

MARITIME PINE (*Pinus maritima*) (Fig. 90).

This pine grows abundantly on the moors of Gascony and upon the littoral of the Mediterranean. Its vegetation is very pretty; it has numerous very long and large leaves, the colour of which is bright green. Its cones are likewise wide and long.

The trunk of this tree is never quite straight, and this defect, added to the inferior quality of the timber, renders it unfit for masts.

As a set-off to this, however, this tree provides plenty of timber for carpentry and firewood; moreover, a large quantity of tar is extracted from it.

CORSICAN PINE (*Pinus laricio*) (Fig. 91).

This is a magnificent tree, excelling the forest pine in size and height, the whole of it being also straight. The leaves are longer, and its fruit is larger and longer. Like the forest pine, excellent masts can be made from it, though it has plenty of sapwood, which rots easily. This notwithstanding, the timber from it is largely used in carpenters' work of large dimensions.

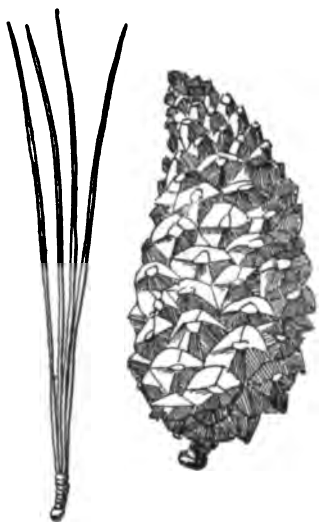

FIG. 90.

FIG. 91.

CIMBRIAN PINE (*Pinus cimbra*).

This variety is met with in the Alps and upon the mountains of Savoy; it is also found in Siberia, always being very small. The seeds, which are as large as peas, are edible.

The wood from this tree is employed in buildings and also by sculptors. The Tyrolean mountaineers make whips from it.

AUSTRALIAN PINE (*Pinus Australis*).

This valuable tree is seen uninterruptedly in the lower portions of Carolina, Georgia, and Florida, upon a wide stretch of ground. The average height of it is about 80 ft. Its leaves, which are of a beautiful brilliant green colour, are very long.

The timber of this pine contains but little sapwood. The resinous matter, which it contains in large quantity, distributed between layers of wood more regularly than in the other descriptions, renders it stronger, more compact, and denser. It will take a brilliant polish. This diversity of qualities makes it preferable to the other species of pine.

A considerable quantity of it is exported to India and Europe.

The resin of this tree is the more abundant as the soil upon which it grows is more or less of a sandy nature.

PITCH PINE (*Pinus rigida*).

This variety is met with upon the littoral of the Atlantic. Light, tractable, and sandy soil is especially suited to its growth. Upon gravelly and sandy soils the timber of this tree is compact, heavy, and contains a large amount of resin.

It is employed for a variety of purposes, and has been for some time in demand for the building of Swiss cottages and light furniture.

"LORD WEYMOUTH" PINE (*Pinus strobus*) (Fig. 92).

This is a very beautiful tree, but is very sensitive to cold and heat. It accommodates itself to all descriptions of soil. Its timber, suitable for numerous purposes, is largely employed in shipbuilding.

FIG. 92.

FIG. 93.

COMMON OR YEW-LEAF FIR-TREE (*Abies taxifolia*) (Fig. 93).

This fir-tree grows naturally upon the lofty mountains of the north of Europe, where it forms vast forests. It is less known in France, and

is a beautiful pyramidal tree, quite straight, the branches of which arranged in rows, extend horizontally.

The fruit is almost cylindrical, and always clings together vertically like that of the cedar.

A fir fifty years old may have attained a height of about 130 ft. Its bark is always smooth, and at a certain age large bubbles full of turpentine are formed under its epidermis.

The wood of the fir is very resilient, and as it is very light, these two qualities make it very suitable for the manufacture of musical instruments. It is largely used in shipbuilding, as well as in the joinery industry. Its bark serves to tan leather, and the leaves are often used as fodder for sheep.

Pitch Pine Fir (*Abies picea*).

The north of Europe, the Alps, and the Vosges contain large quantities of this tree, which is pyramidal and of rapid growth. The trunk of it is very straight, and the branches are very short and ramified. The leaves are numerous, thin, short, pointed, and of a dark green colour.

The timber of this tree has the qualities of that of the common fir. Rosin is drawn from it by incision.

White Fir (*Abies alba*).

This fir belongs to the coldest regions of America and Canada. It receives its name from its leaves, which are of a very pale greenish colour.

The root-fibres, when macerated in water, are both flexible and solid; stripped of their pellicles, the Canadians employ them for joining the barks, of which they form their boats.

The bark provides a rather good tan.

Black Fir (*Abies nigra*).

Thick forests of this tree are met with in every country comprised between a latitude of 45° and 55° by 55° to 75° longitude.

This tree grows very high, and the top of it presents a beautiful, regular pyramid.

Strength, lightness, and elasticity are the principal qualities of its timber; it provides excellent masts, and especially the best yards. It is often employed for shipbuilding in general, often in substitution of oak. A bitter beverage, which is considered a very good preventive of scurvy, is made with its young branches.

PART III.

DIVISION OF THE USEFUL VARIETIES OF TIMBER IN THE DIFFERENT COUNTRIES OF THE WORLD.

CHAPTER VII.

EUROPEAN TIMBER.

THREE large botanical regions are to be distinguished in Europe.

The *Northern Region* includes Lapland, Iceland, and the provinces of the north of Sweden, Norway, and Russia. In this cold part the woody varieties form but a hundredth portion of all the plants that are found there. The trees are principally represented by the conifers and amentaceous plants.

As a rule, the oak, nut-tree, and poplar stop at the sixtieth degree of latitude, the ash at the sixty-first, the beech and the lime at the sixty-third, and the conifers at the sixty-seventh.

M. Charles Martins says that at Drontheim the commonest trees in the gardens are the mountain-ash and lilac. He noticed four oaks which appeared to suffer from the cold.

The ash is a more robust tree, but in Sweden it does not grow to such dimensions as the oak; this *savant* also noticed ash-trees at a latitude of 61°. The lime can live at Drontheim like the balm-tree, poplar, and horse-chestnut tree. All the fruit trees can only be cultivated as espaliers. In the neighbourhood of Drontheim clusters of alders, birches, and firs, mixed with ash-trees, maples, aspens, cherry-trees in clusters, nut-trees, juniper-trees, and willows, crown the higher ground.

The *Middle Region* of Europe comprehends all the countries which form the provinces of the South of Russia, Germany, Holland, Belgium, Switzerland, the Tyrol, the British Isles, Upper Italy, and the greatest

part of France. In this region forests are formed by the following varieties:—The *Common Oak*, or *Quercus robur*, to which are contiguous the *Chestnut-tree*, *Beech*, *Birch*, *Elm*, *Yoke-elm*, *Alder*, etc. The *oak* dominates.

In the *Southern Region*, formed by the littoral of the Mediterranean, the *Kermes Oak* and the *Evergreen Oak* are met with. Besides groves of odorous *Myrtles of Strawberry-trees*, magnificent *Oleanders* are found on the seashore.

In Italy, Sicily, and Spain the *Orange-tree* blossoms and becomes covered with fruit. The forests there are formed essentially by the *Evergreen Oak* (*Quercus ilex*), *Cork-tree* (*Quercus suber*), to which are mixed characteristic shrubs, like the *Erica arborea*, *Cythises*, *Odorous Broom*, etc.

Among the characteristic varieties of these countries may be cited: The *Cypress*, *Kernel Pines*, *Aleppo Pines*, *Laricio Pines*, *Platanes*, and especially the *Olive*, *Lentisk*, *Carob-tree*, *Pomegranate*, and the *Pistachio*.

Over a large part of the southern shores of Sicily one variety of palm-tree only (the *Chamærops humilis*) is met with, accompanied by *Orange* and *Lemon-trees*.

FRANCE.

Although France has still more than 22½ million acres of woods and forests, or the sixth part of its territory and the twenty-seventh part of the total area of the forests of Europe, yet that is far from sufficient for the production of timber.

France provides scarcely a third of the quantity which she requires, and almost all the wood for building purposes comes from other countries, at the cost of more than four million pounds per annum.

The area of ground which it would be useful to replant with trees is estimated at about 2,750,000 acres. But whatever zeal is brought to this work of restoration, whatever the direct advantages of replanting for the cultivator, as in the plantation of truffle-oaks, it would take at least a century of well-directed efforts before all the desired results would be obtained.

It is after this lapse of time that the valuable varieties, especially the oaks, would succeed the resinous ones of rapid growth, which are used for the early covering of ravine slopes.

The annual French production exceeds 40 million stères, made up thus: three-sixths by the region of the north-east, two-sixths by the south-east and north-west, and one-sixth by the south-west.

The annual consumption amounts to 60 million stères. An enormous deficit therefore arises, which compels France to have recourse principally to Norway, Russia, and America.

Fig. 94.—Cutting of a Trunk of Maple.

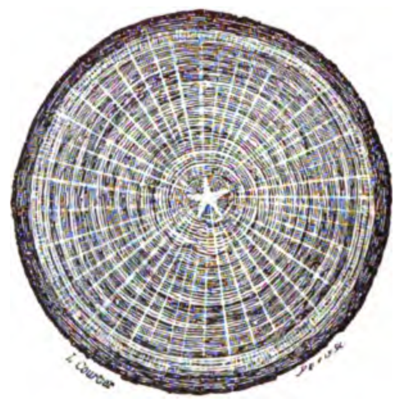

Fig. 95.—Cutting of a Trunk of Oak.

In whatever climatic region one places himself, it will be observed that the French forests are composed of one or several dominating varieties, in the midst of which other isolated species are met with which never form compact groups.

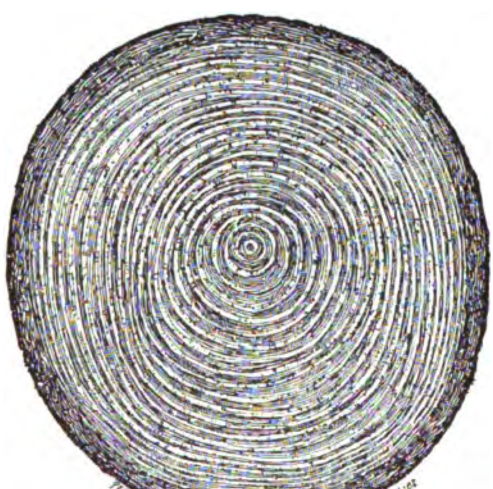

Fig. 96.—Cutting of a Stem of Fir.

Hence two categories: on the one hand, the species susceptible of furnishing a group constituting a forest, and on the other, the isolated varieties, more or less numerous, according to circumstances, but incapable of living and perpetuating in groups.

Thus, in the warm region, the varieties which compose the large groups are the *Aleppo Pine*, *Maritime Pine*, the *Evergreen Oak* or *Yeuse*, and the *Cork-tree*.

In the mild region are found the *English* and *Pedunculated Oaks*, *Chestnut-tree*, *Yoke-elm*, *Sylvester* and *Laricio Pines*, *Beech*, and *Fir*.

In the cold region we meet with the *Beech*, *Hooked Pine*, the *Fir*, *Pitch Pine*, and the *Larch*.

FIG. 97.—Horse-Chestnut Tree.

And last, in the very cold region the *Larch* and *Cembrian Pine*.

All the other varieties of the forest vegetate in their respective regions only in the state of secondary varieties, disseminated according to certain local circumstances in the midst of large groups, presenting numerically only a very small proportion relatively to the dominating species.

The forests which cover French soil are divided into three categories:

(1) Demesnial Forests.

(2) Forests of Parishes and Public Establishments.

(3) Private Forests.

The first cover a superficial area of about 3,750,000 acres, the second 6,250,000 acres, and the third cover about 13,750,000 acres.

In France timber is divided into five classes, namely—

(1) Hard wood.

(2) White wood.

(3) Resinous wood.

(4) Fine wood.

(5) Cabinetmaking wood.

The first class includes the *Oak*, *Elm*, *Beech*, *Ash*, *Yoke-elm*, *Chestnut-tree*, *Sycamore*, *Acacia*, *Maple*, and *Plane*.

The second class comprehends the *Birch*, *Alder*, *Poplar*, *Aspen*, *Willow*, *Horse-chestnut*, and the *Lime*.

In the third class resinous timber is ranged, namely, the *Pine*, *Fir*, *Larch*, *Cypress*, and the *Yew*.

Fine timber is represented in France by the *Wild Cherry-tree*, *Mountain Ash*, *Dog-Berry-tree*, *Pear-tree*, *Apple-tree*, *Strawberry-tree*, *Plum-tree*, *Service-tree*, *Medlar-tree*, etc.

And lastly, the fifth class borrows some varieties from the first and fourth classes, including, besides, the *Acacia*, *Box-tree*, *Nut-tree*, *Apricot-tree*, and *Almond-tree*.

This general sketch of the richness of French forests may be terminated by giving the complete account, in groups, of the woody varieties which are most abundantly spread in the valleys of the French Alps. These are:

ABIETINEÆ.

Pinus cembra (*Cembrian Pine*).

This is met with in a disseminated state in forests of larch-trees and hooked pines, often along with the fir and pitch pine.

It is a tree of great height, called upon to render great service in the planting with trees land once occupied by forests.

Pinus sylvestris (*Sylvester Pine*).

It only forms pure groups upon lower declivities—upon those, for example, which belong to the Oxfordian stratum. It is almost always cultivated by plantation.

Pinus uncinata (*Hooked Pine*).

This is usually met with in the midst of the pines on the fringe of the forest and in the lower and medium zones of the larch.

Larix Europæa (*Larch*).

This tree constitutes immense forests, from the bottom of high

valleys, where it is mixed with the forest pine, to great altitudes, where it is only exceeded in number by the cembrian pine.

In the intermediary zone it covers large tracts, often alone and often also accompanied by the pitch-tree, the fir, and the hooked pine. It vegetates in all kinds of soil, even amongst the most arid rocks. It is largely employed for replanting purposes.

Abies excelsa (*Common Pitch Pine*).

This species is found in company with the forest pine and larch, sometimes in isolated numbers, at others in more or less bushy clusters.

It constitutes in itself important groups, and is abundantly spread upon the lower sides of mountains, but becomes very rare upon higher declivities.

Abies pectinata (*Pectinal Fir*).

This is found in most forests, above the zone of the forest pine, most usually in a disseminated condition. It is not employed much.

ACERINEÆ.

Acer pseudo-platanus (*Sycamore Maple*).

This is generally employed on the Alps, upon the alluvium of weirs.

Acer opulifolium (*Maple, with Laburnum Leaves*).

This tree is rather widely spread, capable of being used in lower dry soil and principally in black earth.

Acer campestre (*Sylvan Maple*).

This tree forms copses in every situation; it is valuable for the replanting of trees in black soil.

AMYGDALEÆ.

Prunus brigantiaca (*Briançon Plum-tree*).

This is a shrub, being generally found in hedges disseminated in the middle of meadows in high valleys.

It is used for replanting dry slopes.

Prunus spinosa (*Thorny Plum-tree*).

This is common in hedges.

Cerasus avium (*Wild Cherry-tree*).

This is met with in woods and meadow-woods of lower declivities.

Cerasus padus (*Cluster Cherry-tree*).

Very common in hedges and wooded dales.

Cerasus mahaleb (*St. Lucia Wood*).

This is met with on stony slopes.

BETULACEÆ.

Alnus incana (*White Alder*).

This tree lines the borders of streams, and follows them in all their windings. It is very useful for the replanting with trees of ravines.

Betula alba (*Common Birch*).

This is disseminated here and there in damp woods.

CELASTRINEÆ.

Euonymus Europæus (*European Prickwood*).

This forms the coppices and hedges of the low mountains.

CORNEÆ.

Cornus sanguinea (*Sanguineous Dog-Berry-tree*).

This tree only constitutes lower woods, thickets, and hedges. It is not largely employed.

CUPULIFEREÆ.

Quercus sessilifloxa (*White Oak*).

Mixed with other species, this oak forms poor coppices upon the lower declivities of mountains.

Fagus sylvatica (*Common Beech*).

This variety is met with near Barcelonnette, in the resinous forests, disseminated in the midst of rocks.

OLEACEÆ.

Fraxinus excelsior (*Common Ash*).

This tree is found in woods and meadow-woods upon banks of stretches of water, in ravines. It is a very valuable variety, on account of the provender which its leaves furnish and also of its timber.

Ligustrum vulgare (*Common Privet*).

This is found in lower woods and hedges.

PAPILIONACEÆ.

Cytisus Alpinus (*Cytisus of the Alps*).

This forms forests in the high mountains, very advantageously employed at great altitudes.

Cytisus sessilifolius (*Cytisus with Sessile Leaves*).

This is found in the coppices and pine woods of the low mountains upon loose earth and in black soil.

POMACEÆ.

Thorny Hawthorn (*Cratægus oxyacantha*).

Berry Hawthorn (*Cratægus monogyna*).

These are two varieties which grow in inferior woods. They are employed the same as the briar.

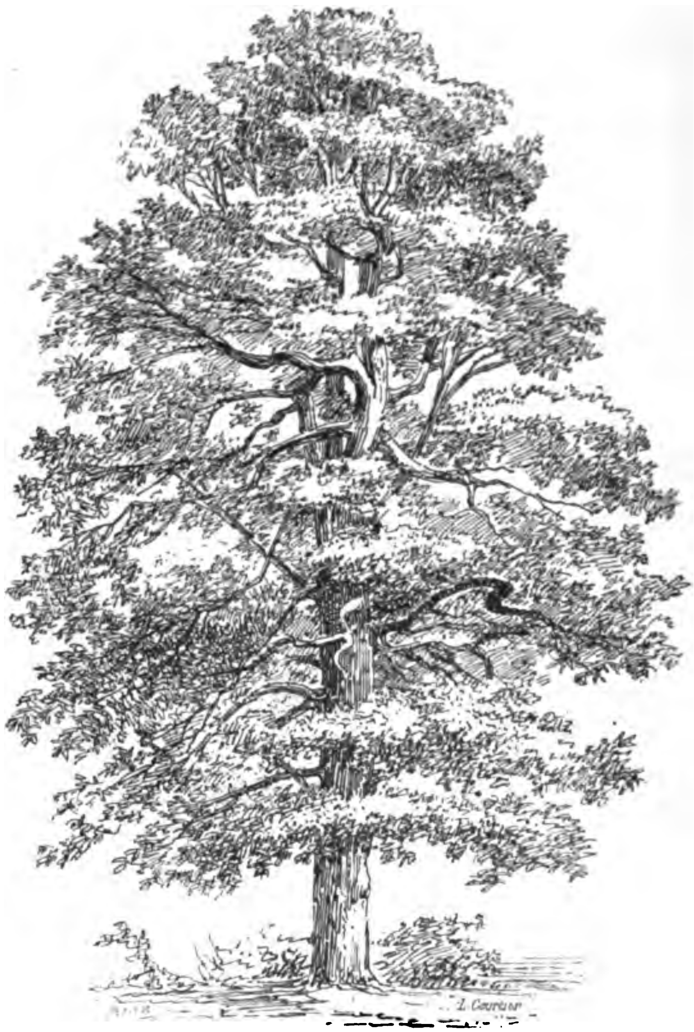

FIG. 98.—Lime.

Service-tree of the woods (*Sorbus terminalis*).

This wood is rather rare and but little used.

White Service-tree (*Sorbus aria*).

This is found in mountainous forests and meadow-woods, and is, like the foregoing, but little used.

Crab Apple-tree (*Malus acerba*).

This is uncommon.

Mountain Ash (*Sorbus aucuparia*).

Mountainous woods, meadow-woods, and crevasses of rocks contain this plentifully, even to the greatest altitudes.

SALICACEÆ.

Yellow Osier (*Salix vitellina*).

This is a variety of the white willow, very frequent along water-courses, being largely employed in the making of faggots and wicker-work.

Red Osier; Purple Willow (*Salix purpurea*).

This is very common in hedges and along streams, and even at great altitudes. It is also found in small ravines. Like the preceding, it is largely employed in faggots and wicker-work.

White Poplar (*Populus alba*).

This is but little used, and is rarely met with.

Black Poplar (*Populus nigra*).

This is very common along the banks of streams, even in the medium zone.

Aspen Poplar (*Populus tremula*).

This tree often forms woods entirely by itself. It is found alike in inferior woods, in the centre of meadows, and in clusters of scattered trees.

Marcescent Willow (*Salix capræa*).

But little diffused, and is only met with in woods and forests which are in fresh situations.

TILIACEÆ.

Large-leafed Lime (*Tilia platyphylla*).

This is uncommon, growing better in coppices and fresh soil; it is employed upon the alluvium in cool ravines.

AUSTRIA-HUNGARY.

Forests and woods figure prominently amongst the natural wealth of Austria-Hungary, and the groups of trees which are found accumulated there greatly exceed the requirements of this empire.

Not only their variety in species and varieties, but also their moderate price, ensure the products of the forests of Austria-Hungary against European rivalry.

The Adriatic Sea, the Vistula, Elbe, Danube, and other rivers and streams emptying themselves into the Black Sea facilitate the exportation by this country of timber of every variety and description.

These advantages have given a development to the exportation of timber of Austria-Hungary which continues to increase.

The principal centres of production are:—In the south: Croatia, Sclavonia, the provinces of Illyria, and Tyrol; in the west: Galicia, Cracow, and Bukhovine; in the north-west: Silesia and Bohemia. This last country is the least wooded. There the forests represent from 25 to 30 per cent. of the superficial area of the country. A much larger proportion exists for Croatia and Sclavonia, where forests occupy 47 per cent. of the territory.

The principal exported timber is:

White Oak (*Quercus alba*).
Black Oak (*Quercus nigra*).
Fir (*Abies pectinata*).
Pitch (*Abies excelsa*).
Larch (*Larix Europæa*).
Austrian Pine (*Pinus Austriaca*).
Sylvester Pine (*Pinus sylvestris*).
Beech (*Fagus sylvatica*).
Ash (*Fraxinus excelsior*).

Illyria furnishes the most beautiful quality of oak, *Quercus pubescens.*

In Tyrol the most valuable larch grows, as well as the pitch pine, which is largely employed in sounding-boards. The most esteemed comes from Paneveggio Forest.

The most beautiful forest pines are met with in Galicia and Bukhovine.

The sale prices of the different Austro-Hungarian timber may be established upon the following averages:—

Shipbuilding Timber.

	The Décistère.
Black oak	1s. 8d.
Elm	1s. 3d.
Ash	1s. 5½d.
Fir	from 1s. 8d. to 2s. 6d.
Pitch	from 10d. to 2s. 6d.

Wood Cleft for Casks.

Oak	1s. 0d.
Maple	10d.
Beech	7½d.

Ordinary Carpenters' and Uncleft Wood.

	The Décistère.
Oak, pine, and larch	8d.
Pitch pine, ash, maple, and chestnut-tree	7½d.
Fir	7½d.
Beech, yoke-elm, acacias, and lime	4½d.
Birch, poplar, and willow	4d.
	The Stère.
Beech, yoke-elm, and maple	1s. 3d.
Oak, elm, and birch	1s. 3d.
Pitch, fir, and lime	8d.

SPAIN.

The forests of Portugal and Spain, which present the greatest analogy to each other, contain a vast number of varieties, the regular cultivation of which is organised with great difficulty, for the efforts of men of science to improve the condition and to secure the preservation of forests, so useful to Spain, are often miscarried, in the face of civil discords and the penury of the public treasury.

Nevertheless, we may cite, amongst the woods cultivated in the kingdom, the ashes, pistachios, platanes, elms, willows, olives, almond-trees, lemon-trees, sumac, nettle-trees, different varieties of oaks, and especially the cork-tree.

Spain provides a large portion of the cork consumed in the world. It exports it to France, England, Belgium, Italy, Austria, Switzerland, Russia, Egypt, United States, Canada, Central and Southern America, India, Japan, and China.

In 1886 the exportation of cork from Spain was 1,200,000 thousands of corks, of a value of £920,000. The importation into France is, unfortunately, four times as large as that from Algeria.

Almost all the Catalonian cork is employed in ordinary corks, and a large portion in corks for champagne bottles, which are the dearest, and are distinguished by their fineness, elasticity, and durability.

In the inferior productions Spain makes corks which are only worth tenpence a thousand.

The surface occupied by forests of cork-trees in Spain amounts to about 1,375,000 acres.

GRAND DUCHY OF LUXEMBOURG.

From time immemorial this country has been one of the most thickly wooded of Europe. Its soil was formerly covered by the Ardennes Forest, *la forêt profonde*, one of the most remarkable by its extent

of all those known in antiquity. This forest, however, did not form a continuous group, but included glades, cultivated or inhabited by aboriginal tribes.

Since then, however, this country has suffered the fate of all the others, and immense clearings away have taken place.

In 1830 two-fifths of the superficial area of the Grand Duchy were still wooded, 252,500 acres of forests being then reckoned on. In 1888 this figure dropped to 195,000 acres.

Actually, therefore, the extent of the forests represents less than the third of the total surface of the country, which places it in Europe in the ninth rank.

The wooded properties are natural plantings composed of a small number of leafy varieties, amongst which may be mentioned the beech, pedunculated oak, English oak, and yoke-elm; then follow the sylvan maples and sycamore, aspen, birch, ashes, wild cherry-tree, and alder, which are only met with in scattered groups.

The resinous varieties found there are of recent introduction, classed according to their importance, as follows: forest pine, pitch, larch, and fir.

The forests of the Grand Duchy were already, in early historic times, stocked with beech-trees, oaks, hazel-trees, and thorns, without evergreen trees. The first conifer introduced into forest culture was the fir of the Vosges. At Inckelsbusch it was found about 130 years old.

The pitch-pine came afterwards. In 1772 it was introduced into a manorial wood of Bissen, along with the sylvester pine and the fir of the Vosges.

To-day the principal products of the forests are:

	Annual Average.
Ordinary Cuttings.	
Clearing cuttings (hectares)	1,230
Timber. Trees, uncleft (number)	29,000
Firewood (number of stères)	57,000
Firewood. Fagots and piles reduced to fagots	1,350,000
Barks (quintals)	4,800
Extraordinary Cuttings.	
Clearing cuttings (hectares)	70
Timber. Trees, uncleft (number)	4,700
Firewood (number of stères)	5,000
Barks (quintals)	490
Clearing Cuttings.	
Clearing cuttings (hectares)	60
Timber. Trees, uncleft (number)	20
Firewood. Fagots	430,000

The money value of all of these products represents an annual average of about forty thousand pounds.

ITALY.

The resources of the forests of Italy are still very important, though, instead of increasing, they are on the down-grade.

Although the trees of the North may still have numerous representatives in Italy, especially upon the elevated slopes shaded by the oaks and

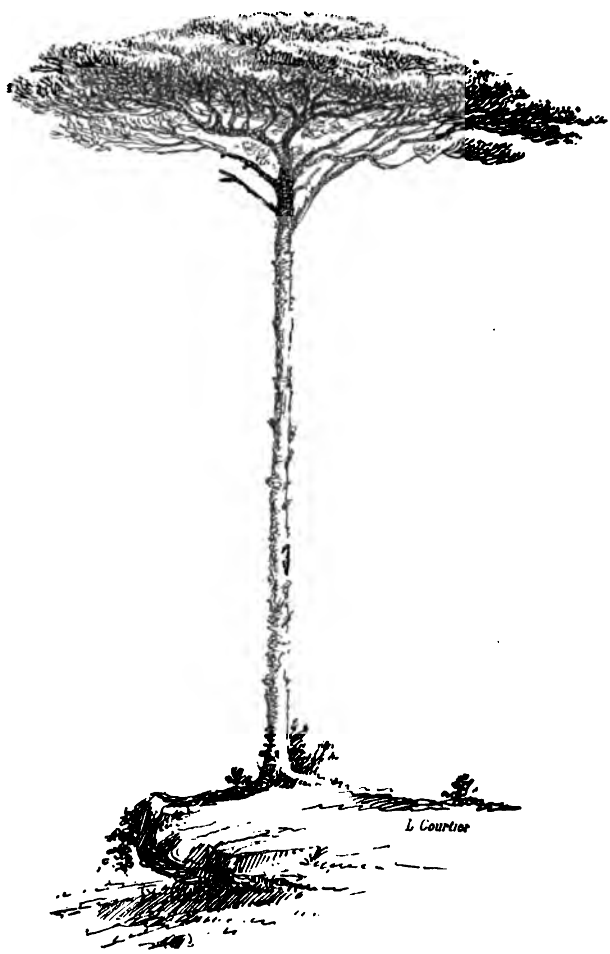

FIG. 99.—Italian Pine.

pines, the olive-tree—that representative typical of the vegetation in the warm, temperate zone—is the dominating variety in the rich forests of this country.

There still-exist in the Apennines and upon the slopes of the Alps

Fig. 100.—Chestnut-Tree on Etna.

important groups of beech-trees, pines, and chestnut-trees, in the ancient Lombardo-Venetian kingdom.

The fir-coned pines form a magnificent forest of 12,500 acres in the neighbourhood of Ravenna, and are very valuable.

Tuscany contains very beautiful forests of oaks, principally cultivated by the English.

In Sardinia magnificent oaks are cultivated, which are greatly in demand by the navy. Indeed, the island annually furnishes more than three million kilogrammes of large timber, destined for the building of ships. The famous chestnut-tree of Etna may be mentioned, which is more than four thousand years old, measuring 60 metres in circumference, and which can shelter more than a hundred horses under its immense foliage.

GREAT BRITAIN.

In this country, which was formerly nothing more than an immense forest, it is estimated that only the twenty-fifth portion of its territory is covered by woods, but replantation is being actively carried on, and young forests are in the majority there.

Highly-esteemed old oaks are still to be found in rather large quantities, which are used in naval constructions, in spite of the remarkable facilities which England finds of supplying itself with exotic timber of superior quality.

NORWAY.

The quality and cheapness of Norwegian timber finds markets for it over the entire surface of the globe.

About a third of the timber for building purposes which is imported into France comes from Norway.

There is every reason to believe that in former times about half of the superficial area of this country was wooded; at the present time, however, the total surface of Norwegian forests can scarcely be estimated at a quarter of the extent of the country.

There are several causes contributing to this decrease in the wooded surface.

In the first place, there is the clearing of the land of trees, in order to obtain arable land and meadows. It may also be added that the consumption of the products of forests has increased considerably by reason of the constant growth of the population, and also that, as in

many other countries, forests have often been abused without discretion and principle. In addition to these permanent causes, great fires have contributed in a disastrous manner to the denuding of the land of trees.

In elevated countries it has also been noticed that mountains become devoid of trees on the top, in consequence of the widespread and often necessary usage of having summer cottages upon the high plateaux.

According to the most recent data, the extent of the forests of Norway is equal to a little more than a quarter of the total superficial area. The most thickly-wooded countries are the prefectures of Akershus, Smaalenene, and Jarlsberg; those which are the most destitute of forests are the prefectures of Finmarken, Tromsœ, and Stavanger.

About 80 per cent. of the total surface of forests are in the hands of private individuals.

The forests, so-called, consist principally of the pine (*Pinus sylvestris*) and fir (*Abies excelsa*). In some places one or other of these varieties grows alone to the exclusion of the other trees; in others the forests are mixed.

The pine, though not as common as formerly, is, however, met with everywhere, and in Finmark there are continuous large forests composed exclusively of pines.

At 60° of latitude north, the pine grows to 3250 ft. above the level of the sea, and at 61° up to about 3085 ft. In the Nordre Gudbrandsdal, the most central district of Norway, it is found at 2925 ft.

Farther north the limit of growth of the pine is lower, and at 70° it attains but little more than 650 ft. above the level of the sea.

The fir, which some people consider as only being of later introduction into Norway, grows principally in Eastern countries, where it forms, either alone or with the pine, immense forests, stretching in general the length of long water-courses. Upon the western side it is but rarely met with in a native state at the south of the sixty-second degree of latitude. From the sixty-third to the sixty-fifth it is, however, also found in islands. Farther north it becomes more and more rare, and at the height of the polar circle it ceases to form forests. In the east of Finmark, by 69°, it is still met with, though isolated.

The limit of vegetation of the fir is, as a general rule, from 260 to 325 ft. less elevated than that of the pine.

The pine and fir rarely attain in Norway more than about 100 ft. in height; their growth varies greatly, moreover, from one place to another.

In the south of the country a pine of 75 to 100 years old may

furnish carpenters' timber from about 23 ft. in length, and from about 8 in. in diameter as a minimum. In propitious conditions the fir is fit for felling at the age of 70 to 80 years. But as a rule the pine is not ready for felling until about 150 years old; and even in a number of places neither the pine nor the fir attain the desired dimensions before the age of 200 years.

It is principally the pine and fir which contribute to the consumption of the country the wood for building purposes and as fuel, as well as to the enormous exportation of Norwegian timber, which is in such demand on account of its beautiful qualities. The constantly increasing employment which has been made, in the last few years, of the Norwegian fir for the manufacture of mechanical and chemical wood pulps for paper-making may also be mentioned—an employment to which it is particularly adapted on account of the small amount of resin which it contains.

The roots of the pine are employed in certain places in the manufacture of tar, but there is not even enough of it to supply the requirements of the country. Almost everywhere tan is made with the bark of the fir.

With regard to other conifers, Norway produces in the wild state the juniper-tree (*Juniperus communis*) and the yew-tree (*Taxus baccata*), but these are without importance as regards forest cultivation.

The forests of pines and firs occupy together about 75 per cent. of the total wooded surface.

The trees with caducous leaves are principally the birch (*Betula*), two species of which are come across in Norway: the birch of the valleys, or white birch, and the birch of the mountains.

The first is common in the countries of the south, and is found there even up to altitudes of 1625 ft. above the level of the sea.

The second abounds principally in Finmark, where it occupies about 90 per cent. of the total surface of the forests of this country. In the south, up to 62°, the limit of vegetation of the birch rises to 2575 ft.; in the east of Finmark to about 650 ft. above the level of the sea. The birch may attain a height of from 65 to about 81 ft., with a diameter of about 5 ft. breast-high.

In Norway the birch is principally employed as firewood. It is also useful in the making of various household utensils and staves; its first white bark is employed in a number of usages, especially in the covering of country houses.

There are still in Norway other trees with caducous leaves which are more or less distributed; amongst others, the aspen, largely employed in the manufacture of matches; about twenty varieties of willows and

osiers, two species of alders, then the elm and chestnut-tree. The limit of vegetation of the osier rises to 4875 ft. above the level of the sea.

Of still less importance and less widely spread are the ash, plane, and lime.

In the woods of the southern coast, and also in part along the western coast, the pedunculated oak; and, more rarely, the English oak are met with. As a matter of fact, the oak is generally felled and barked for the production of tan, rather large quantities of which are exported each year. From 1875 to 1885 the average annual exportation of this product rose to 465,000 kilogs.

A certain quantity of staves is also made in oak wood, though this species of timber is but little used in marine construction.

The annual consumption of timber from the forests of the country is divided as follows, according to the use to which it is put:—

	Cubic Metres.
Household requirements and cultivation of land .	10,000,000
Firewood and for building purposes in towns .	1,530,000
Building timber for vessels and boats . . .	200,000
Working of mines and works	350,000
Railways, telegraphs, bridges, etc.	20,000
Total . .	12,100,000

By adding to this the annual figure of the exportation of wood and of wood pulp, which was, in 1885, 2,200,000 cubic metres, the total figure of the production of timber of the country is obtained, namely, 14,300,000 cubic metres.

The felling of forests is done principally in winter—from the month of October. The wood sold is then taken to the nearest navigable river; it is there marked with the buyer's axe, and in the spring, upon the thawing of the snow, it is borne to its destination by the freshet.

The production of worked wood has taken, in the last few years, a considerable development; the greatest portion of exported timber is previously sawed and planed; carpenters' goods (such as doors, windows, etc.) are also made from it.

According to ancient documents, the exportation of timber from Norway originated before the twelfth century. But it is especially since the epoch when the exploitation of the natural riches of the country passed from the hands of the Hanseates into those of the Dutch that the exportation of the timber from Norway took a great extension.

By reason of the small number of vessels which, at this period, still composed the mercantile fleet of the country, the Norwegians scarcely

participated in the transportation of the timber. The Dutch came with their ships, principally to the shore between Christiansand and Drammen, in order to load the timber which they transported into Holland in the form of beams.

The timber trade became in general for this part of the country what the fisheries were for the west of Norway—the principal source of wealth. It was the more flourishing, as, at its commencement, it could be practised with freedom. Towards 1805 this commerce attained wonderful prosperity.

The following table shows the value, in francs, of the exportations of Norwegian timber during the years 1876, 1883, and 1887 :—

	1876. Francs.	1883. Francs.	1887. Francs.
Planed timber . .	16,700,000	23,200,000	17,300,000
Sawed timber . .	19,800,000	15,600,000	11,900,000
Squared timber . .	4,200,000	2,100,000	1,500,000
Timber of mines. .	6,300,000	7,300,000	5,000,000
Staves and chests .	2,300,000	2,700,000	2,100,000
Wood for burning .	800,000	900,000	1,000,000
Total exportation .	50,100,000	51,800,000	38,800,000

In conclusion, it may be said, as to the geographical distribution of the exportation of timber from Norway, that during the year 1887 England received sixty-three hundredths of the whole production, France nine hundredths, Belgium seven hundredths, Holland six, Germany four, Australia three, Denmark two, Sweden one, Spain one, and other countries four hundredths.

PORTUGAL.

This country presents the same flora and distribution of forest species as Spain.

In the low region are found—*Celtis Australis, Citrus aurantium, Cupressus glauca, Morus alba, Laurus nobilis, Olea Europœa, Pinus pinaster, Pinus pinea, Quercus ilex,* and *Quercus suber.*

In the mountainous region — *Acer campestre, Buxus sempervirens, Castanea vesca, Fagus sylvatica, Quercus Lusitanica, Quercus tozza, Betula alba,* and *Juniperus communis.*

The varieties which dominate in the south and centre are the maritime and kernel pine. This cultivation has been developed upon the seashore to protect the beach after the French method, giving very good results.

The forests of cork-trees also play an important *rôle* in Portugal.

ROUMANIA.

Roumania must be classed amongst the most thickly wooded countries of Europe, its forests covering an area of 5,000,000 acres, about half of which belong to the State.

The mountainous districts are the most thickly wooded. The wooded

FIG. 101.—Platane of Bujukdéré.

surface diminishes in proportion as one advances towards the Danube, where forests are rather rare.

From the point of view of the distribution of forests Roumania may be divided into three regions:

(1) The region of the high mountains, which can be limited to the most elevated summits of the Carpathians. The fir, larch, pine, dwarf juniper, and birch are found there almost exclusively. The yew is met with upon the high mountains of small Wallachia and Western Moldavia. There the forests cover twenty-five hundredths of the superficial area.

(2) The hilly region, where one meets especially the beech, which covers enormous surfaces, then the birch, ash, English oak, maple, cherry-tree, and mountain ash. The pear-tree, apple-tree, medlar-tree, walnut-tree, hazel-tree, and in certain forests of smaller Wallachia the chestnut-tree, thrive there in a wild condition. In this region forests cover twenty-seven hundredths of the surface.

(3) The region of the plains, in which the evergreen oak, tauzine oak, *Quercus cerris*, sylvan maple, platane maple, sycamore maple, yoke-elm, elm, ash, lime, nut-tree, dog-berry-tree, sloe-tree, acacia, and the spindle-tree. In the islands of the Danube and the low plains upon the sides of rivers and ponds, various species of willows, poplars, alders, aspens, tamarinds, and other shrubs are found.

There are few forests which can be submitted to regular management. The modes of cultivation most used are *jardinage* and universal felling, leaving some reserves. Upon the high mountains regular cultivation is hardly ever met with.

In the mountainous region the State possesses 54 per cent. of the total forests, 26 per cent. in the hilly region, and 17 per cent. in the region of the plains.

In 1887 the importation from neighbouring States, notably from Austria-Hungary, was:

	Francs.
Firewood	61,000
Charcoal	135,000
Wood for building	1,346,000
Industrial timber	4,485,000
Total	6,027,000

The following statistics represent the exportation during 1890:

	Francs.
Firewood	64,000
Building wood	3,400,000
Industrial timber	655,000
Total	4,119,000

The timbers for building are sent, as a rule, to Panama, the resinous wood to Constantinople. The oak timber goes to Fécamp for the French market.

It is since 1882 that the timber industry commenced to take a definite development in this country. Roumania possesses to-day more than sixty steam saw-mills, without counting 200 hydraulic saw-mills.

The largest part of the exportation consists of resinous timber and articles manufactured from it.

The principal timber manufactures are, as regards the resinous varieties, boards, which serve to cover roofs, as likewise to make laths, trunks, tubs, casks, etc. The hard species, and especially the oak, are useful in the making of staves, inlaid floors, sleepers for railways, and planks of different sizes. Beech is principally fashioned into the utensils used by the peasants.

In 1888 the sale of forests and their products provided the State with a sum of about £88,000.

Besides timber and firewood, the forests furnish several products, such as charcoal, resin, tinder, potash, and bark.

Charcoal is especially made in forests bordering on large towns. Young wood is principally employed for its manufacture, and special varieties are made from it: the oak, yoke-elm, maple, and elm.

The resin is collected and put in cases in fir-bark, which are sold in the towns. It is employed in the manufacture of varnish and to perfume apartments.

Timber is the essential and indispensable material for the building of houses, especially in country places where there is a scarcity of stone and where the largest part of buildings, foundations, walls, and roofing are entirely made of wood. The varieties which are most often employed are the oak and fir, followed by the yoke-elm, beech, and elm.

The industries practised in forests are bushel-making, cooperage-work, sawing, and basket-work.

In the country, timber almost entirely replaces metals, crockery, and glassware. For this usage the poplar, willow, beech, alder, and fir are especially employed.

Pieces of timber for cartwrights' work and joinery—such as fellies of wheels, axle-trees, mill-shafts, and tomb-crosses (which the peasantry transport and sell wholesale in villages and at fairs)—are also cut up in the Roumanian forests.

Thanks to its climate, Roumania produces timber of excellent quality, and which is hard, being durable for a long time. It is not rare that oaks, firs, and beeches, the trunks of which have diameters exceeding 10 ft., are met with.

In the Garj district a large trade is done in the wood of the walnut-tree. These trees are sold by the trunk, and not by the cubic metre.

The price varies between 100 and 200 francs the trunk, according to the dimensions and qualities.

Wood for burning purposes is sold at a maximum of 1 franc the stère, and wood for working, such as the oak, ash, and elm, from 20 to 30 francs the stère, delivered free to station.

RUSSIA.

Amongst the natural wealth of this empire still remaining almost unexploited may be mentioned the forests, which for the most part still present the appearance of virgin forests.

Finland, the governments of Olonetz, Wologda, Kastroma, and Archangel possess enormous forests.

Of the 200 million acres constituting the government of Archangel, 75 millions are covered with forests belonging in part to the administration of the navy. One district alone, that of Mesen, possesses about 37 million acres of forests.

The State possesses in the grand duchy of Finland about 25 million acres of forests.

Unfortunately, however, in Russia, as in so many other countries, the forests have been greatly neglected for a considerable time. For the last twenty years, however, great efforts have been made, which are to-day crowned by success. Access to many forests has become easier by the creation of ways of fresh communication both by land and water, and the forest industry, aided by steam applied to the sawing of wood, produces more rapidly and economically.

The inequality of distribution of forests in Russia is very striking. The richest zone is included between the fifty-sixth and sixty-fourth degrees of latitude.

Forests preponderate especially upon the declivities of the White Sea and Baltic. In these regions the government possesses 200 millions of wooded acres.

In spite of this abundance of forest-products, certain parts of the empire, away from the large wooded groups, have to pay very dearly for their firewood.

The pine is the tree principally met with in Russia. From north to south, the principal varieties are the following:—

Pinus cembro, Ulmus effusa, Alnus glutinosa, Acer platanoïdes, Pinus larix, Quercus pedunculata, Pinus sylvestris, Carpinus betulus, Quercus robur, Fagus sylvatica, Tilia Europœa, Acer campestre, Acer tataricum.

The rapidity of growth diminishes towards the north, but the quality becomes ameliorated.

The timber whose exportation is the largest must be ranged in the following order, so far as regards the different parts of Russia:—

North	Pine. Fir. Pitch-tree. Larch.
North-east	Forest pine.
West	Oak. Lime.
East	Beech. Elm. Maple.
South	The different European varieties.

SWEDEN.

Sweden has been celebrated for some time for its wealth of forests, which not only supplies it with sufficient timber to meet its own requirements, but allows it to do a huge export trade, in fact the shipments of timber account for half the total export of the country.

The Swedish forests are principally composed of varieties of pines and firs, mixed with birch-trees, alders, and aspens. The oak is also grown in the provinces to the south of Dalelf, and the beech in the more southern ones.

These forests are stocked with pitch-trees and forest pines; the latter preponderate in the proportion of 90 per cent. The forest pine is the tree *par excellence* of the North. It attains in Sweden a circumference and height under branches which is but seldom met with in other parts of Europe.

Besides the forests properly called, large domains possess enormous pasture-lands wooded more or less with the birch, aspen, alder, and oak, and also, though in a lesser degree, with the beech, elm, maple, and lime, as well as different varieties of conifers.

A vast region of the country, Lapland, in which to a large extent the forests are divided between the State and the inhabitants, not having yet been completely measured, it is difficult to indicate in precise figures the total area of forest soil in Sweden.

The whole of the land not occupied by water amounts to about 100 million acres, and a little less than half of this is estimated to be forest, namely, about 42 million acres.

Of the whole forests, 15 per cent. belongs to the State, the remainder

belonging to individuals; but the extent of the forests placed under the direct administration of the State increases year by year by the purchase of private forests.

The economy of the private forests is not submitted to any administrative control; there are, however, in this respect, the following exceptions:—

In the Isle of Gotland, bad management or the dilapidation of forests has involved the forbidding of the cultivation of wood for sale. Along the hilly region of Norrbothnie the exportation and sale of sawed wood have been forbidden for dimensions of 208 mm. in diameter to 5 metres above the root. Latterly, in Lapland, the above law has been made applicable to all private forests, to whatever class they may belong.

Until now the forest cuttings have only been introduced in a very small portion of the private forests of Svéaland and Götaland.

In Norrland, where the largest forests are situated, the felling of lofty trees can generally only be done in the vicinity of towns. The reason of this is that this region, with a sparse population, possesses hardly any other industry than its saw-mills and its exportation of timber, and that these trees alone have the large dimensions which are in demand for the saw-mills and exterior commerce.

The erection of large mechanical saw-mills, established in view of commercial cultivation of land, only dates about forty years back.

In the last century, and until 1810, the wholesale exportation of building timber was forbidden. The free trade in forest productions, decreed in 1846, gave extraordinary scope to the cultivation of forests.

Sweden depends almost exclusively upon its forests for the combustible necessary to its metallurgical industry. The production of charcoal has also been undertaken upon a large scale in the majority of the provinces, and principally in the large mining regions belonging to the middle portion of the country.

The annual consumption of firewood is of prodigious proportions. Except as regards the larger towns, timber always remains the building material employed in almost every habitation. Then follow the firewood necessary for industrial establishments, the wood for working, building-wood for ships and crafts, and especially unheard-of quantities of young timber, required for the luxurious enclosures (*gärdesgärdar*), in quartered wood, planted obliquely in the ground and bound by branches of fir-tree or osier, enclosures separating not only domains, but also the cultivated fields from each other and from the paths and highways.

If the important annual exportation is added to this home use of

timber, there will be found, for the total exploitation of the forests, the amount of 50 million cubic metres.

Particulars of this exportation are shown in the following table:—

	Pieces.	Cubic Metres.
Girders and small beams of large dimensions	500,000	3,000,000
Girders and small beams of small dimensions	1,500,000	2,000,000
Building timbers, masts, and yards	600,000	2,000,000
Sleepers	600,000	100,000
Mine-props	12,000,000	3,000,000
Planks and joists (dozens)	6,000,000	40,000,000
Ends of planks	...	1,500,000
Splints	...	150,000
Laths	600,000	...
Firewood	...	1,000,000
Hoops of casks	150,000	...
Timber for oars	40,000	...
Staves of beech	30,000,000	...
Staves of oak	2,000,000	...
Rough wood	150,000	...
Worked wood	4,000,000	...
Bark	...	100,000

The timber of Sweden is largely in demand, and each year important consignments of it are sent even to Australia, the Cape, Brazil, etc.

More than a half of the Swedish exportation is absorbed by England, followed by France, Denmark, Belgium, Spain, etc. Almost all the mine-props are sent to England.

The exportation of the largest timber took place principally from the ports of the Gulf of Bothnia, between the large rivers of the Dalelf and Angermanelf.

It is in this hilly region that the largest and most numerous mechanical saw-mills are found.

These mills are very numerous, their number being computed at more than 2000.

With regard to the transport of wood, this is largely effected by means of floating.

In conclusion, the large quantity of worked wood exported by Sweden comes from numerous manufactories of wood-flooring and joinery.

CHAPTER VIII.

AFRICAN TIMBER.

FROM the point of view of forest cultivation, Africa may be divided into three principal parts—

(1) The northern part, which includes the Mediterranean seacoast and the Sahara.

(2) The central or tropical part.

(3) The Cape region.

In the first region the *Olive-tree* is found very extensively, and constitutes one of the principal sources of wealth of the Kabyle tribes; then the *Cork-tree*, which forms immense forests in the lower part of the mountainous region of the littoral, notably in the province of Constantine, where this timber has become the object of very important cultivation.

Among the other wood varieties found in this part of Africa, the *Tamarisk* and the *Atlantic Mastic-tree* may be at once cited; followed by the *Date-tree*, which is cultivated not only for the abundance and variety of its products, but also for its shade. Besides the date-tree, the majority of the oases present, in rather large abundance, the *Fig-tree*, *Pomegranate-tree*, and the *Apricot-tree*. The *Peach-tree*, *Wild Quince-tree*, *Pear-tree*, and *Apple-tree* are especially planted in the oases situated towards the mountains.

The *Citron*, *Orange*, and *Olive trees* are more rarely met with in the oases.

EQUATORIAL REGION.

In this part of Africa some botanical species, which are ordinary plants elsewhere, here assume a ligneous aspect.

Upon the damp shores impenetrable forests are developed, formed of *Mangroves* and *Avicennias*. *Banana-trees*, some gigantic Malvaceous plants like the *Baobab*, and some Aloes and Euphorbia are met with in large numbers there.

In these warm regions the numerous tribe of Palms is manifested.

First and foremost comes the *Oil-bearing Palm-tree* of Guinea, the fruit of which contains an enormous quantity of oil. The sap of this valuable tree gives wine, and its leaves serve as fodder. But the true viniferous palm-tree of these countries is the *Sago-tree*.

Fig. 102.—Baobab.

SOUTHERN REGION.

The region of the Cape of Good Hope presents a great variety of timber, of which mention will be made later; it is also especially the country of the gigantic heathers, these attaining several feet in height.

The *Leucadendrons* may also be cited, one species of which, called "silver-tree," grows to about 32 or 39 ft., its branches charged with lanceolate, silky, and silvered leaves.

ALGERIA.

Of all the French colonies, that which possesses the most forests is undoubtedly Algeria.

The information here given as to the forest-wealth of this colony is extracted from the most recent official documents, published in 1899.

This country, from the point of view of the production of timber, may be divided into three regions, namely—

The *Mediterranean* or *Algerian Tell region.*

The *high plateaux.*

The *Sahara.*

The region of the littoral of the Constantine province and of a portion of the Algerian province as far as the limit west of the Djurdjura group deserves special description, because of the characteristics which it presents both from a geological and forest point of view.

This region is characterised, from a geological point of view, by crystalline schists, together with grits and marls of the nummulitic formation, with outcrops of primitive rock. Of the 1,135,000 acres of forests of cork-trees which Algeria possesses, 1,042,000 acres are on this formation.

Outside of this zone, the primitive and transition formations no longer exist except in places upon a narrow band of the littoral.

Excluding some few rare exceptions, the Algerian forests occupy the mountainous regions. Admirably situated upon the summits, and facing the direction of the currents of warm air which rise from the sea charged with humidity, they fulfil there one of the most useful *rôles* which Nature has assigned them.

The utility of forests no longer needs demonstration as concerns the purely mechanical effect of the consolidation of the soil, the warehousing of the waters, and of the supply of springs.

It is known, moreover, that some springs may disappear through local clearings of land of trees, when otherwise it would be right to conclude that the annual quantity of rain had diminished.

			Millimetres.
The average rainfall is		upon the littoral	887
„	„	in the Tell	590
„	„	upon high plateaux	369

In Western Europe the average flow of the rivers amounts to between a quarter and a half of the volume of rainfall; in Algeria, upon the Mediterranean declivity, it is only one-twentieth. This flow is certainly increased by the trees which adorn the head of the basins.

According to the last statistical information compiled in 1888, the superficial area of the forest-soil in Algeria may be estimated at

8,120,000 acres, of which 5,212,500 belong to the Mediterranean region, and the remainder to the Sahara mountain-sides.

The following table will show the extent of the forests in the three departments:—

MEDITERRANEAN REGION.

Departments.	Territorial Extent.	Extent of Forests.	Degree of Wooding.
	Acres.	Acres.	Per cent.
Algiers	7,650,000	1,203,500	15·7
Constantine	9,780,000	1,693,560	17·1
Oran	9,225,000	2,305,992	25·1
SAHARA MOUNTAIN-SIDES. HIGH PLATEAUX.			
Algiers	18,403,500	785,660	4·3
Constantine	10,483,750	1,327,708	12·7
Oran	19,674,000	792,765	4·0

This table shows that the acreage of forest is 19 per cent. of the total land in the Mediterranean region and 7 per cent. in the region of the high plateaux.

In France, whose territorial extent is 132,100,000 acres, the extent of the forests of all sorts is equal to 23,502,500 acres, which gives a forest acreage equal to 18 per cent., whilst the general average of Europe is from 29 per cent.

As regards thickness of growth, the majority of the Algerian forests cannot be compared with those of France. Among the causes which have impoverished them, and which render amelioration very difficult, may be mentioned fires and immoderate pasturage, thus preventing complete planting afresh with trees, as also the rewooding of the empty spaces.

The principal varieties of trees are divided as follows:—

	Acres.
Cork-tree	1,134,500
Zeen oak	134,500
Evergreen oak	1,845,000
Aleppo pine	2,077,500
Cedar	95,000
Thuja	395,000
Wild olive	87,500
Various	2,345,000

The province of Constantine is by far the most thickly wooded, the extent of its woods and forest amounting to 3,022,500 acres.

The principal products of the Algerian forests—those which provide maintenance to the exportation of commerce—are:

(1) Cork.

(2) Building timber (ships, house-building, railway-sleepers, staves, etc.).

(3) Fancy wood (parquetry, cabinetmaking, marquetry, fancy turnery, etc.).

(4) Resins.

(5) Tanning barks, etc.

In accordance with Mussulman law, forests were the property of the State, and the French occupation confirmed this principle. With the exception of some alienations, the forests of the three Algerian departments have remained demesnial property.

The following are the principal *indigenous varieties*:—

Evergreen Oak (*Quercus ilex*).

The evergreen oak is the most extensive. It is found alone, and also often intermingled with the Aleppo pine. This tree shoots out very well from stocks when it is young, and throws off shoots very abundantly at all ages. The production of sprouts is ensured by burning upon the spot the *débris* of the felling after cultivation. Its wood, which is very hard, presents a density varying from 0·9 to 1·18. It furnishes an excellent firewood, and is greatly used in joinery and carriage-work. It acquires with age a very beautiful colour—a deep brown, and jet-black in the centre; its bark is highly appreciated for tanning.

Cork-Tree.[1]

We now come to one of the most important species of trees. Algeria is the true country of the cork-tree; it contains as large a quantity of them as all the rest of the globe put together, and produces a cork the quality of which is recognised as equal to that of the best productions of Spain and Portugal, and which improves with the culture of the forests.

This tree is indigenous to the north of Africa and the south of Europe. That living on the heaths of Gascony belongs to a special variety—the western oak.

[1] In French, *liège*; Portuguese, *severo*; Spanish, *corcho*; Provencial, *suro, suvi*; Italian, *soghero*; and Arabian, *kerrauch, sernan*.

The principal stations of the cork-tree are the northern shores of Africa, Portugal, Spain, the south of France, Corsica, Sardinia, and Sicily. It is unknown in Syria, as also in Asia Minor.

The cork-tree, of the family of evergreen oaks, has the same bronzed foliage, with metallic reflections of the ilex and ballot oaks, but it is very stumpy, its canopy more irregular and with less foliage, and its bark characteristic.

Of moderate size, for its height does not generally exceed 63 ft., it has a thick trunk, thanks to its longevity, and varieties with a 3-ft. diameter are often met with in Algeria.

This species, firmly rooted, often tap-rooted, gives forth in rocky soils numerous running roots, which, running sometimes to the surface of the soil, follow the contour and penetrate into the fissures, providing

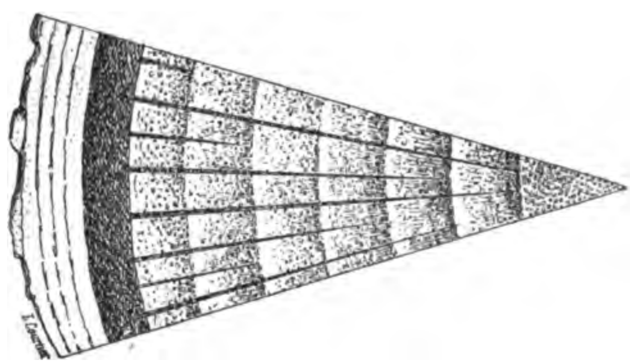

FIG. 103.—Medullary Rays of a Trunk of Cork-Tree.

the tree with a strong hold and permit it to withstand the strongest hurricanes.

Few trees of the forest are endowed with such great vitality; cut level with the ground or burnt as it stands, the cork-tree sprouts out, even up to a very advanced age, and it is owing to this special quality that numbers of Algerian forests are preserved, in spite of devastation by fires.

Upon the Algerian littoral the cork-tree grows as well on the plain as upon the mountain; it grows better, however, upon broken ground and slightly elevated hills. It is rarely seen above a height of 2925 ft. This tree accommodates itself to almost all kinds of soil, except pure limestone and compact clay. As a rule, it prefers granites, schists, and sandstone.

The wood of the cork-tree is heavy, compact, and difficult to work. It warps and cracks deeply in drying. It is therefore of little use; it is sometimes used by country wheelwrights, and boat-builders use it in

the making of angles and curves. Atmospheric variations rapidly change it, when it rots very quickly. Cabinetmaking and joinery trades could employ it with advantage, for its colour is very beautiful.

On the other hand, it is excellent as firewood, and the charcoal which is obtained from it is of exceptional quality. Its density varies from 0·8 to 1·03.

The foliage of the cork-tree is retained for two years by the tree; notwithstanding that its covering is very light and permits of the underwood developing freely, forming thickets which are often impenetrable.

Flowering usually takes place towards the end of April, though it varies according to the situation and altitude.

The acorns ripen and fall from the end of October until January. Generally abundant, rather large, very bitter to the taste, they are consequently unfit for food.

The bark of the cork-tree comprises two concentric layers, which are quite distinct and naturally different. The interior zone, which is found in direct contact with wood, is formed of a grained matter, slightly elastic, intermixed with a fibrous tissue, and it is an active part of the bark. It corresponds to the liber of the other trees, and contributes to the formation of the cortical and woody layers of the tree, of which it constitutes one of the essential organs. It is this portion which the ancient cork-cutters called *mère*, and what in Algeria is to-day more commonly designated by the name of *tannin.*

Everywhere where this layer is destroyed upon the body of the tree, there is formation neither of bark nor wood, unless the wound has just become cicatrised and as a consequence covered by the growth of neighbouring tissues. Complete, or even partial, decortication, when it makes the tour of the trunk, is a certain cause of the death of the tree.

The second layer, forming the exterior zone of the bark, is thicker than the preceding, and is composed of a spongy matter, which is elastic and compressible, slightly permeable to liquids, constituting what is called the *suberose* or *ligneous tissue.* It may be considered that this layer is an inert envelope, participating in the growth of the tree, though not contributing towards the active functions of vegetation—which explains how the tree may be deprived of a portion of its suberose covering without its existence being in any way compromised.

After this deprivation, indeed, a new layer of the same nature is formed, and the operation, practised with care, may be periodically renewed.

A new layer of bark, between the newly formed bark and wood, is produced each year; it then happens that in the course of multiplication

they press the network of older cortical layers and force it to become distended. The exterior layers end by getting dismembered, forming, on the trunk of the tree, deep longitudinal crevasses.

The yearly layer forming in the bark of the cork-tree is in reality double; each of the cortical zones increases on its side, this growth being made upon the interior surface of the last-formed layers. This growth does not resemble liber; as to cork, on the other hand, the resemblance is very pronounced and easily recognisable. The annual layers of cork, like those in the majority of woods, are lined upon the interior by a series of cells of a dark colour; these cells can be easily distinguished from one another and the age of the cork determined.

The male or virgin cork is the suberose bark which the tree produces naturally. This bark develops with the tree, grows with it, cracks as it gets older, never becoming detached naturally from the trunk, as has often been erroneously asserted. It may attain an enormous thickness. Barks about 1 ft. in thickness are found on old oaks.

The tree getting older, the resistance which the old cortical layers opposed allows of a very feeble development in formation of the new layers: the result is a cork without elasticity, cracked and without possible applications.

This male cork is therefore of little or no value, It is, however, often employed for the rustic decorations of parks or gardens.

If the tree is deprived of its natural cork, taking care not to damage the inferior layer of the bark or liber, there is seen to form, after a certain time, a new layer of cork called "reproduction" or "female" cork, in contrast to the "male" or "natural" cork. It is this new matter which is the true commercial cork; its advantages are its homogeneity, elasticity, and non-cracking.

When its male cork is taken away from the tree, the operation called *démasclage* (stripping the tree of its bark) is proceeded with. By this operation the oak is placed in a state of forming "reproduction cork"; it is, therefore, valuable; for it is only from now that the tree becomes really productive.

The cortical layer of the liber contributes alone to the formation of the cork of reproduction; the name *mère* has also been given to it. But this matter has besides become the object of an important commerce under the name of *tannin*; both denominations are employed, especially the latter, in Algeria.

M. Mathieu thus sums up the process of formation of the "reproduction cork":—

"The denuded *mère* becomes more or less dried upon contact with the atmosphere; at first of a rose colour upon the surface, it soon passes to an ochreous red, and finally to a blackish brown. It is between this hardened zone and the portion of the *mère* remaining active that the new cork is formed, at a changeable depth and in a very variable region as a consequence—that is to say, sometimes in the herbaceous envelope and sometimes between that and the liber, often in the thickness of this latter. Whatever the layer may be which the female cork regenerates, the latter, once reconstituted, grows by itself on its internal surface, just the same as the male cork."

It is, indeed, in this manner that things go on. The *mère* has not entirely grown outside. The action of growth after stripping causes it to be divided into two portions; the dried-up exterior part separates from the part which is usually very thin and which remains active, and it is between this latter, adherent to the wood and in communication with the liber of the superior part not yet stripped and the exterior portion, where the first layer of female cork is formed.

The drying up of the *mère* is afterwards prolonged, as it dies under the male bark at a certain distance below the *démasclage* section. The formation of the female cork commences afterwards.

As soon as the first layer of this new cork is formed, the suberose bark continues to grow with regularity, and as for the wood, the thickness of the layers formed annually accords with the age and vigour of the tree, as well as the conditions of plantation.

The layers of a cork of good quality ought to present themselves regularly, and of normal thickness. If this thickness is too extreme, the cork becomes soft, being penetrable by liquids; it is then given the name of *fatty* or *puffed cork*. In general, it is damp shallows which produce this kind of cork.

When the growth is very feeble—that is to say, when the layers are thin and contracted—the cork is no longer elastic. Its density is then more pronounced, which makes it unsuitable for commerce. This latter fault is most often brought about by the nature of the soil upon which the tree is found. Corks of this variety are generally produced upon impoverished soils, which are elevated and exposed to the west.

In respect of thickness, the cork is furrowed by canals of a brownish colour, always directed perpendicularly to the bark. These canals are the medullary rays, which, at first cylindrical, afterwards assume an elliptical form, under the influence of lateral pressure, and finally become completely flat. These medullary rays are coated inside with

cells, which are easily destroyed, then leaving holes in the cork full of dusty matter.

When these holes are too abundant, the quality of the cork decreases and its impermeability diminishes.

Upon the ventricle of the block of cork—that is to say, upon its interior surface—the medullary canals are signalled by small apertures, generally elongated as regards its height and surrounded by a thin pad. The nature of the cork can therefore easily be judged by examination of the block. When the latter is soft and the apertures signalised are small and rare, one may be sure that the cork is homogeneous and of good quality. In the case, on the other hand, where the interior surface of the block is riddled with a large number of blackish holes, the cork would be found of mediocre quality, perforated and cracked upon the interior.

If a cork of the first reproduction and a male one, taken from the same oak, be compared, it will be proved that a modification is produced in the texture of the new suberose coating; the principal characteristics of this modification are the obliteration and disappearance of a portion of the medullary canals, and as a consequence the compactness and homogeneity of the cork are augmented.

Moreover, the less compressed annual layers show more elasticity, the external surface is not so deeply cracked, the quality of the cork being therefore improved.

Like fruit-trees, cork-trees have their own individuality—that is to say, the stock which gives fine cork at the first gathering will continue to do so, and, on the other hand, the tree whose cork is at first perforated will continue to give products of a mediocre quality.

The growth of cork is very variable, as the following table will show:—

ANNUAL GROWTHS.

	Thin Corks.	Ordinary Corks.	Thick Corks.
	Cms.	Cms.	Cms.
Formed the first year . .	0·0017	0·0037	0·0050 to 0·0062
,, second ,, . .	0·0025	0·0040	0·0055 ,, 0·0070
,, third ,, . .	0·0023	0·0038	0·0052 ,, 0·0067
,, fourth ,, . .	0·0022	0·0036	0·0048 ,, 0·0062
,, fifth ,, . .	0·0021	0·0034	0·0043 ,, 0·0057
,, sixth ,, . .	0·0020	0·0032	0·0040 ,, 0·0052
,, seventh ,, . .	0·0019	0·0028	0·0037 ,, 0·0047
,, eighth ,, . .	0·0017	0·0025	0·0035 ,, 0·0045
,, ninth ,, . .	0·0015	0·0022	0·0032 ,, 0·0042
,, tenth ,, . .	0·0013	0·0020	0·0030 ,, 0·0040
,, eleventh ,, . .	0·0012	0·0018	0·0027 ,, 0·0037
,, twelfth ,, . .	0·0011	0·0018	0·0025 ,, 0·0035
,, thirteenth ,, . .	0·0010	0·0016	0·0022 ,, 0·0035
,, fourteenth ,, . .	0·0010	0·0016	0·0020 ,, 0·0032

AVERAGE THICKNESS OF CORKS.

Ages.	Thin Corks.	Ordinary Corks.	Thick Corks.
	Cms.	Cms.	Cms.
At the age of five years	...	...	0·0248 to 0·0318
,, six ,,	...	0·0217	0·0288 ,, 0·0370
,, seven ,,	...	0·0245	0·0325 ,, 0·0417
,, eight ,,	...	0·0270	0·0370 ,, 0·0462
,, nine ,,	...	0·0292	0·0402 ,, 0·0504
,, ten ,,	...	0·0312	0·0432 ,, 0·0544
,, eleven ,,	...	0·0330	0·0459 ,, 0·0581
,, twelve ,,	0·0215	0·0348	0·0484 ,, 0·0616
,, thirteen ,,	0·0225	0·0364	0·0506 ,, 0·0651
,, fourteen ,,	0·0235	0·0380	0·0526 ,, 0·0683

These figures are the averages of corks of the same category; they are the types which usually appear.

Naturally the diminishing progression of thicknesses is often irregular, and sometimes annual layers are found which are thicker than those formerly formed. This often happens when a very dry year succeeds a very rainy one.

In general, cork should not be gathered before having attained a thickness of 22 mm. Too frequent stripping would drain the tree and the gathered corks would be of bad quality.

Commercially, cork only commences to be saleable at dimensions of 28 to 30 mm.

The density of cork varies the same as that of wood: it depends upon the nature and age of the tree.

Ordinary corks at the age of ten years have a density scarcely equal to 20 cms.

It will be seen farther on that the principal use of cork lies in the formation of all sorts of stoppers. It is, moreover, largely employed by industry under different forms, notably in the making of insulated casings of steam machines.

Up to now no natural product has been discovered to replace cork. Several plants are, however, known the bark or pith of which is somewhat analogous to the tissue of the cork. It is thus that in Brazil the bark of a tree of the *Bignoniaceæ* family furnishes a sort of cork; but the qualities of these rare products in no manner rival those of the cork, so called, which remains one of the principal sources of wealth of Algeria.

ZEEN OAK (*Quercus Mibeckii*).

The zeen oak is a special variety growing chiefly on the Barbary shore, and grows in soils which preserve freshness the whole year. It is

especially met with in deep ravines exposed to the north; it is only when at an altitude of more than 2000 ft. that it is found upon slopes exposed to the south. Groups of zeen generally form elongated woods according to the direction of the ravines, and are surrounded by plantings of cork-trees.

These groups present, as a rule, the same aspect, consistency, and stocking. They are usually constituted of old forest-trees ungrafted or by lofty poles of shoots of stumps that have grown in consequence of fires and strewn with reserves which have been saved from the ravages of fire. Small wood and thickets are also generally found, rather thick in parts, in the centre of old plantings and upon the borders where young zeens are likely to be substituted for cork-trees.

The zeen oak is a tree of great grandeur, and is one of the most useful and beautiful products of the Algerian forests. Its height often reaches 100 to 110 ft., and its diameter is sometimes equal to about 6 ft.

In consequence of the position it occupies in fresh parts of forests, it grows rapidly, gives a fibre-like wood of a yellowish colour, sometimes rose-coloured, and of horned consistency. The medullary rays are numerous, raised, broad, and close to one another. They produce magnificent veins when the wood has been cut in a way parallel to their direction.

The wood of this variety is heavy; its density is higher than that of the European, caducous-leafed oaks, excepting those of Italy. When it is green, it is heavier than water. Thus:

The density of	dry zeen oak	is equal to	0·924
„	Provence oak	„	0·861
„	Burgundy oak	„	0·760 to 0·805
„	Dantzic oak	„	0·734
„	Galicia oak	„	0·718 to 0·762
„	Italian oak	„	0·982 „ 1·009

Zeen oak never presents thick layers of porous wood, as are met with in oaks grown upon immersed soils in the spring. This arises from the fact that the slopes upon which it grows retain their freshness the whole year, and are protected, by virtue of their slopes (which are generally steep), against an excess of humidity.

It is with difficulty that this wood becomes dried up. It has even been proved that large pieces of timber had not lost all the water they contained after having been felled ten or twelve years.

Perfect timber resists putrefaction thoroughly, and is preserved for a long time, in spite of alternatives of dryness and dampness.

Railways and other companies who employ it for sleepers have proved that they last much longer than those of any other species.

Zeen oak presents upon bending an enormous resistance, which is the reason of bridge-girders being made from it. As a result of experiments carried out at the naval arsenal at Toulon it was found that the strength of breaking per square millimetre of section is equal to $7^{k}.4$ for zeen oak, whilst it varies from 4·7 to 7·2 for European oaks.

Like its congener, the English oak, of which it is probably only a modification due to the climate, the zeen oak has straight fibres, and is very fit for the saw-mill.

But apart from these advantages, the zeen has the great inconvenience which has been pointed out elsewhere in the other oaks, and which is due to the structure of its timber. It has, moreover, a tendency to warp, chink, and crack. These defects render it unfit for a number of usages.

By taking precautions, however, these defects can be almost completely done away with—in the sawn wood, for example. It is known that joists and planks are more liable to become coloured and cracked when their surfaces are perpendicular to the direction of the medullary rays. This observation, common to all the oaks, is applied *a fortiori* to zeen, the wood of which is fibrous.

Planks of zeen sawed with the grain present a magnificent appearance, and only become coloured when they are in unfavourable conditions for drying. To delay and regulate desiccation, which is the cause of the production of the clefts, the wood may be left for a certain time under the bark, then immerse it in water. This process has given excellent results.

En résumé, in order to extract the best part possible from zeen oak, it is sufficient to adapt the different qualities of wood to the uses to which they are appropriated, to cut down the trees in the winter, to prune them and allow them to pass the summer without bark; then, in the autumn, to cut them into planks as thin as possible and to immerse them. After remaining in the water for from six months to a year, they are allowed to dry in the shade, taking care to air them, to avoid rough transitions of temperature, and especially to preserve them from the sirocco.

As has already been mentioned, zeen oaks are employed in the manufacture of sleepers for railways. Those which have come from slight altitudes and warm situations can also be used as piles for building purposes, hydraulic constructions, carpentry-work of bridges, and, in a word, in every case where strength, solidity, and durability are required.

Those of the northern slopes and elevated regions give a good sawing-wood, staves for large casks, wood for cooperage-work, etc.

Chestnut-Leafed Oak.

This tree inhabits the large and Eastern Kabylie upon mountains whose altitude exceeds 3250 ft., and is a variety of zeen oak which

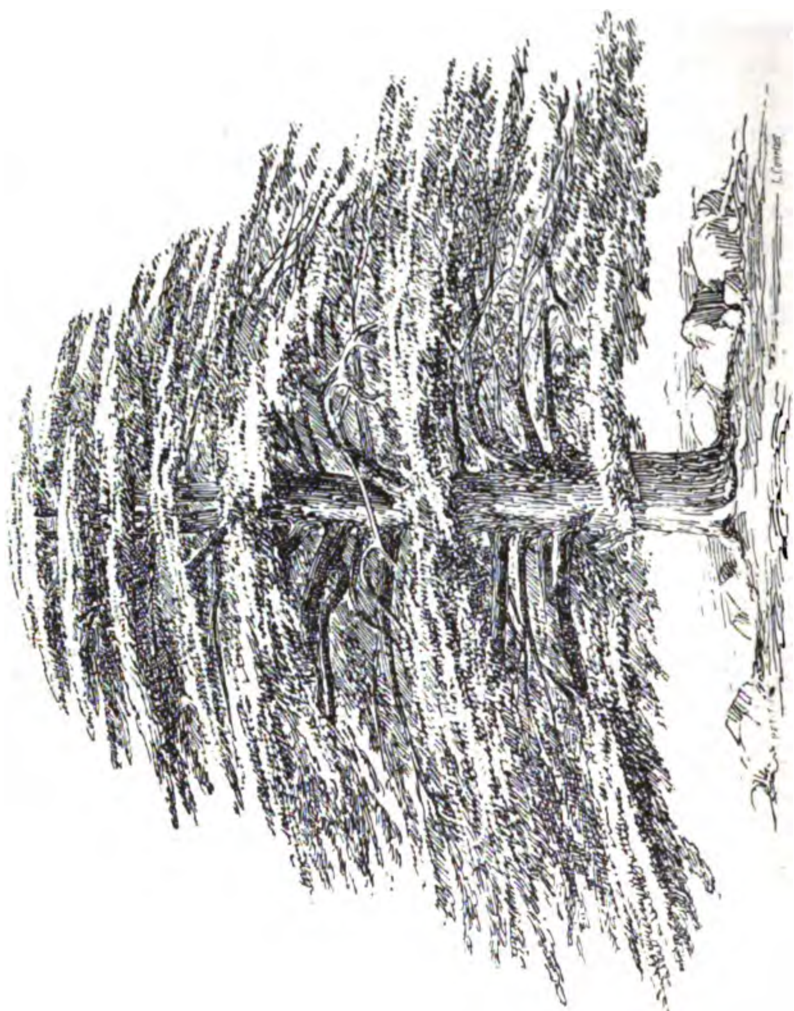

Fig. 104.—Lebanon Cedar.

is often met with. The acorn ripens every two years; the density of the timber, which has plenty of sap, varies from 0·835 to 1·024.

Kermes Oak (*Quercus coccifera*).

Very common upon the African littoral, notably in the Oran province. The roots furnish a tan greatly in demand, and giving rise to

a large trade. The quintal of tanning bark at a timber merchant's yard near the place of cultivation is worth about 8s. 6d.

But this trade is harmful, for the 90,000 quintals of tanning bark exported annually by the province of Oran are obtained by destroying, without possible reproduction, about 180,000 stères of useful wood.

Aleppo Pine (*Pinus halepensis*).

The figures already given show that this is the most extensive variety in Algeria. It prospers in all kinds of soil, and is also found upon the high plateaux of the Sahara. Its timber is more durable than that of the pines of Landes. Preference is usually given to it for the making of telegraph poles.

Maritime Pine (*Pinus maritima*).

This tree is far more rare than the preceding one. The only soils which are suited to it are the old siliceous ones, and especially the trachytes. It forms important forests near Bône and Cape Bangaroni.

Cedar (*Cedrus Libani*).

The wood of the cedar is amongst the most valuable, because of its large dimensions, rigidity, and beautiful red coloration. It is met with on numerous mountains whose height exceeds 4850 ft. The most considerable forests are situated to the east and west of Batna.

The durability of this timber is superior to that of the majority of the resinous varieties. Fine without being too heavy, it is easily worked, does not shrink, and, by its agreeable and penetrating odour, it is not liable to attack by insects. As lining for cabinet-work, it is of great service on account of its odour.

Lignum Vitæ (*Callistris quadrivalvis*).

This tree is common in the Oranian and Algerian Tell, where it often covers immense stretches of land, either alone or mixed with the Aleppo pine. The Constantine province does not contain any of it, but it is again found in Tunisia.

The reputation of *Lignum vitæ* is well known. It is known that with the trunk of this tree furniture of great beauty is made. *Lignum vitæ* was known by the Romans under the name of *Citrus*. Pliny often mentions it, quoting certain prices of tables made from it which are really fabulous—£12,000, for instance.

PHŒNICIAN JUNIPER-TREE (*Juniperus Phœnicea*).

This is a tree which is rather common upon high plateaux. The *macrocarpa* variety is met with especially in the Constantine province.

THE YEW (*Taxus baccata*).

This tree is met with in the Aurès and Djurjura.

THE MASTIC-TREE (*Pistacia lentiscus*).

This variety is extensively distributed in the three Algerian provinces; it is rather rare, however, upon high plateaux, and the Sahara contains none at all. The leaves of the mastic-tree are highly charged with tannin. In America and the English colonies, a process of concentration has been made use of for a long time which permits of tannic acid being extracted from these leaves, and which humidity does not change, and which, also, does not colour leather.

THE CAROB-TREE (*Ceratonia siliqua*)

is found throughout the whole of Algeria. Homer designated it under the name of "the tree of the Lotus eaters." Its culture, like that of the olive-tree, may be made very lucrative, when it is thoroughly understood.

In Egypt, Arabia, Spain, and Italy, the fruit of the carob-tree is comestible and may even be substituted for certain cereals.

THE NETTLE-TREE (*Celtis Australis*)

is found in the forests of Kabyl and in the neighbourhood of Bône. As a dry soil satisfies it, it is largely employed for rewooding. Its timber, which is very elastic, is useful in the making of whip-handles.

THE FRENCH TAMARISK (*Tamarix gallica*)

is common in the three provinces. There are several varieties of it which, joined together, form the Sâada forest, to the south of Biskra.

The other indigenous species deserving of being quoted are the different *Maples*, the *Oxyphilla* and *Excelsior Ashes*, *White* and *Black Poplars*, *White Willow*, *Olive-tree*, *Chestnut-tree*; then in the underwoods, the *Brooms*, *Mastic-tree*, *Buckthorns*, *Myrtles*, *Holly*, etc.

As to the exotic varieties, the principal will first be cited:—

THE EUCALYPTUS,

which is a native of Australia. A hundred varieties have been naturalised in Algeria. Each of them can be appropriated to a special soil. Thus the *Rostrata* and the *Tereticornis* grow in the low and marshy plains, exposed to inundations in winter, but the soil of which is deep; the *Cornuta, Resinifera, Diversicolor,* and *Globulus* are destined for ravines and damp valleys, in good soil; the *Marginata* and *Meliodora* are adapted to high and dry localities and to the mountainous and stony parts; the *Obliqua* and *Bucoxylon* grow better in elevated situations and without shelter, where vegetation is meagre, where winds and drought often occur, etc.

These trees grow very rapidly. The trunk may attain a height of about 330 ft., with about 10 ft. diameter at the base. Their timber is very resistant, durable, and elastic; it is employed in carpentry-work, but must be treated, prior to using it, with steam, otherwise it will crack and bend.

The acclimatised Australian **Acacias** in Algeria are very numerous, the following being the most interesting:—

The *Melanoxylon Acacia,* which is grown from seed in the neighbourhood of Algiers.

The *Biophylla, Pycnantha,* and *Cyanophylla,* which have the property of enduring drought.

These trees grow rapidly, though never reach a great height. The timber from them, which is very good as split wood, is covered by a bark rich in tannin, yielding about 30 per cent. of it.

To sum up, for the growth and exportation of the whole of its vegetable wealth, Algeria is happily supplied by Nature, thanks to its geographical situation and the extent of its coast; and the continuous extension of its highways will permit it, in the near future, to make use of this wealth and to greatly profit therefrom.

TUNIS.[1]

At the present time the wooded groups of Tunis no longer occupy soils which have not been cultivated. The denudation of steep declivities produced by grubbing up has promoted the carrying away of the land, and the subjacent rock is found laid bare in the majority of

[1] The information here given as to the Tunisian forests is extracted in part from the most recent documents, published by the Administration of Forests.

the mountainous groups affected by the unwooding. Moreover, the repeated fires which the natives are in the habit of lighting in order to procure pasturage have also largely contributed to restrict the extent of forest land, so that forests are only maintained upon the mountains, where man has no interest in attacking them. As a matter of fact, the proportion of wooded surface is not more than one-seventeenth of the total area of the country; the forests do not occupy more than 1,870,000 acres, of which only 1,625,000 acres can be cultivated.

These woodings are situated to the north-west of the Regency. Between Mahdia and Sfax, the large forest of Chebba is found, stocked with mastic-trees and philarias.

Upon the interior of the wooded quadrilateral, formed by the Algerian frontier, the sea and the line passing by Hammamet and Feriana, the forest groups are divided into two very distinct groups, one of which occupies the large central angle of Tunis and the other the mountainous group of the north. It is in this last part where the superb forests of cork-trees and of the zeen oak of Khroumirie are found. The high forest does not exist outside of the Khroumirie country; the other districts only contain clumps of trees more or less deteriorated by the hand of man and the abuses of pasturage.

Sometimes the vigour of the vegetation is so developed and the varieties are so robust that plantations of trees have been able to maintain themselves, and it is essential, in order to reconstitute them, to submit them to rational treatment and to rigorous surveillance.

Conformably to Mussulman law — and this is put in force in Algeria—French law has decided that forests formed part of the domain of the State under the reserve of rights of property and usage regularly acquired before its promulgation.

The forest flora of Tunis comprehends 210 varieties, 80 of which can be cultivated for their timber. The species constituting forest-groups are: the cork-tree, zeen oak, holm oak, kermes oak, wild olive-tree, maritime pine, Aleppo pine, lignum vitæ, and the juniper-tree. The other descriptions are found in isolated places and in small clusters in the forests, or are cultivated in orchards, gardens, and oases.

Among the secondary varieties some occupy the bed or banks of water-courses, others constitute impenetrable thickets in the midst of the groups. The sumacs are the last representatives of the ligneous vegetation which persist upon the denuded mountains of the centre and south.

The pinnate ephedra, fibrous calligone, and retem occupy the hollows of the Sahara sandhills.

The woods of estates occupy 1,537,500 acres over the 1,870,000

which exist altogether in the Regency, private woods therefore covering an area of about 487,500 acres.

The principal varieties over this superficial area of 1,870,000 acres are divided thus:

	Demesnial Woods. Acres.	Private Woods. Acres.
Cork-tree	290,000	...
Zeen oak	26,500	...
Green oak	75,500	14,750
Kermes oak	99,500	5,500
Wild olive-tree	41,750	92,500
Gum-tree	87,500	...
Maritime pine	7,500	...
Aleppo pine	377,500	71,250
Juniper-tree	34,250	11,000
Lignum vitæ	7,500	55,000
Other varieties and unoccupied ground	490,000	237,500
Total	1,537,500	487,500

As already pointed out, the most beautiful Tunisian forests are situated in Khroumirie; they are composed of cork-trees and zeen oaks. The maritime pine covers some mountainous remains to the west of Tabarka, and the kermes oak forms the dominating variety of the woodings of the downs. The wild olive-tree is met with in the southern part of the forests of Western Khroumirie; it is mingled with different secondary species: the mastic, myrtle, and philarias.

The forests of the high mountains still include old cork-trees, which constitute the majority of the plantings; their number decreases in proportion as the height diminishes, and old trunks replace them, finally disappearing before the young plantings of trees in the lower lands.

The quantity of oaks capable of producing cork in a period of twenty years, beginning from 1884, has been estimated, by the Forest Mission of 1882, at 13 million.

From this fact a possible annual revenue of £100,000 could be reckoned upon.

Groups of zeen oaks are disseminated in the midst of the cork-trees; they occupy the declivities in exposed situations, as well as the bottom of ravines.

The material which can actually be felled is estimated at 500,000 cubic metres, in uncleft wood.

To the production of corks and fine-arts wood must be added the cultivation of tanning barks, the ordinary uses of the timber of industry,

and the manufacture of charcoal, which may reach each year more than 100,000 metric quintals.

The forests of the other varieties are in too poor a condition at the present time to provide an important revenue. Their production is, however, sufficient to maintain local consumption and to furnish, on some points, products of exportation.

Their yield is, as in the case of the forests of zeen oaks, subordinated to the question of transport.

The Tunisian forests are usually situated in mountainous regions, the soil of which does not lend itself to culture; their destruction would lead to the slipping of the vegetable earth, the sterility of the soil, and the disappearance of the influence which they exercise upon the state of the atmosphere.

The preservation, therefore, of the whole of the forests of the Regency is of the utmost necessity; this is all the easier, as the plantations, though in a bad condition, will reproduce themselves naturally.

As a matter of fact, Tunis imports a considerable quantity of foreign wood, as will be seen by the statement that in 1888 Tunis consumed 11,000 stères of fir-wood coming from Norway, Canada, and Jura.

The trade in timber is less than the wooded surface of Tunis would lead us to expect, which arises from the impoverished state of a large portion of the forest-groups. However, 10,000 stères of zeen oak has been produced by Western Khroumirie, which have been useful in the making of railway sleepers.

The cultivation of firewood and charcoal is of unquestionable importance, but it cannot increase on account of the high price of transportation. It amounts to 300,000 stères yearly, about half of which is provided by State forests.

The manufacture of tar demands each year about 15,000 stères of dead wood; this manufacture, however, is not allowed from May 1st to November 1st.

Following the system adopted for other countries, some special details of the principal varieties met with in the Tunisian forests will now be given.

Almond-Tree.

This tree has been found, in a spontaneous state, only in the Ouled Ayar. It is cultivated for its fruit. The timber, in a perfect condition, is veiny and of a chestnut colour; the sap is white. The medullary

rays, very thin and numerous, produce fine and very conspicuous veins. The commencement of each annual layer is formed by a narrow zone of rather large vessels, which assume a deeper tint and establish a very clear line of demarcation between the successive layers. The wood is hard, compact, very heavy, and liable to crack.

The natives fell those trees which do not give any fruit, and make firewood of the timber obtained thereby.

Azarole-Tree.

This tree grows, in isolated places, throughout the whole of the north of Tunis. It is found in schistous soils. Its timber is white, slightly reddish, and reddish brown in the centre; it is very homogeneous and compact; the medullary rays are thin and numerous. The sap is scarcely distinguishable from perfect wood, which is hard, heavy, and compact, without suppleness. It will, however, take a beautiful polish, and provides an excellent firewood.

Carob-Tree.

This variety grows in all the temperate regions. It is found in the driest calcareous mountains, in the Khroumirie forests, and even in oases.

This tree is found either isolated or in little groups. Its timber is hard, heavy, of a rose colour in the perfect state, with white sap. It is adapted for sawing, and will take a very beautiful polish. Natives cultivate it both for the shade it affords and for the fruit obtainable from it, which is edible.

It is a species which could be very usefully employed for purposes of rewooding, on account of its shade and the value of the products which it supplies.

Cork-Tree.

In Tunis this variety occupies a superficial area of 288,000 acres; it is isolated at Cape Bon, at Enfida, in the Bedjaoua, but forms clusters disseminated in the middle of the kermes oaks, which cover the mountains of Magod, and constitute, in the Khroumirie region, superb groups, the exploitation of which is rendered easy by the vicinity of the sea.

In Algeria this description of oak covers a superficial area of 1,125,000 acres, and the total surface of the forests which have been planted with it in Southern Europe and Northern Africa can be estimated at 3,500,000 acres, half of which belongs to France.

In the Tunisian forests trees of different ages are stripped, which present, after having undergone this operation, an average circumference of about 2 ft. 4 in. The average height to which the trees are barked is about 5 ft.; the productive surface of each of them is about 3 ft. 3 in. square. The net cost of the stripping of the tree has been exceedingly low during the last four years. The work executed by the State is put up to public tender.

Kermes Oaks.

This tree replaces the holm oak upon all the stony soils of the north of Tunis. It is found in all the sands of the northern coasts, where, mixed with the juniper, mastic, and several other secondary varieties, it constitutes very compact plantings, which assure the fixing of the sands. In the large downs of Tabarka it forms a small forest of about 38 acres. The whole of the mountainous group of the Magod is covered with it, as well as the surroundings of Bizerte and the mountains of Cape Bon.

Its timber may be compared to that of the holm oak: it is also heavy, hard, and compact, and shows the same qualities and defects. It furnishes wood fit for building purposes, and a valuable charcoal.

It has been seen that its bark is rich in tannin, but it is especially the root bark which is employed in commerce under the name of *garouille*.

Holm Oak.

The holm oak grows mixed with the Aleppo pine in all the forests which cover the calcareous mountains to the south of the Medjerda.

Very few holm oaks of large dimensions exist in Tunis. Only a few of them are met with in the mountains of the Ouergha and Bargou. The natives have destroyed them by fire, and have killed, by peeling them, those which have been spared from fire. The groups of holm oak present to-day nothing but stumps browsed by cattle and generally too young to be cut regularly for the market.

Zeen Oak.

With the exception of some isolated trees distributed here and there over the hillocks of the littoral, this is only found, in Tunis, in the Khroumirie region, where it occupies about 26,500 acres.

The total volume actually cultivable in Tunis is estimated at 500,000 cubic metres, distributed by halves in the groups of Central Khroumirie and in those of the environs of Ghardimaou.

Since 1883—the epoch of the organisation of the forest service in Tunis—only railway sleepers have been drawn from it, and this will always remain its principal use.

The creation of the network of forest-routes of Western Khroumirie has allowed the commencement of the exploitation of groups of zeen oak in this region and of auctioning fellings each year, from 1883 to 1889, whose total volume has been about 11,000 cubic metres of rough timber.

The buyers have only cut sleepers from the timber which have been sold at the price of 3s. 9d., delivered at the Ghardimaou Station. The purchase price of the cubic metre on the spot has varied from 3s. 9d. in 1883 to 8s. 9d. in 1888. The sleeper, which is about 8 ft. in length, by 9 in. in width, and having a thickness of about 5 in., weighs about 75 kilogs. one month after having been cut, and costs 10d. for working purposes. The cubic metre of rough timber provides from nine to ten of them.

The development taken by the culture of the vine in Tunis demands the annual consumption of an enormous quantity of oak wood for the barrelling and transport of the wine.

In 1888 the produce of the 7500 acres of vines planted in Tunis since 1884 was 15,000 hectolitres. It will, therefore, be easily computed what an enormous quantity of timber will be required by this industry when the vines have attained their normal yield and the plantations have developed.

Wild Quince-Tree.

This tree is cultivated throughout the whole of Tunis. It is frequently met with in garden hedges. The timber in a perfect condition is not distinguished from that of the white hazel-tree; it is very heavy; it is heavier than water, and is compact, homogeneous, of a reddish-brown colour, with lines and spots of the same colour, though deeper.

Juniper-Tree.

Tunis possesses three species of juniper-trees: that with large fruit, the oxycedar juniper, and the Phœnician juniper. This variety occupies about 45,000 acres.

The large-fruit variety is formed upon the northern downs. It grows rather rapidly, attaining a circumference of 4 ft. 9 in., with a height of about 19 ft. to 23 ft. The oxycedar is rare in the north, but becomes

rather common in elevated parts of the forest of the central chain. The wood, which is red in a perfect state, with very fine grain, susceptible of receiving a beautiful polish, warps slightly, being adapted for marquetry-work and the lathe.

The Phœnician juniper-tree is less rare in the north, where it is met in warm situations; it is rather common in the forests of the central chain, where its station is not so elevated as that of the other. Its wood is brown and yellowish; and it polishes easily.

The natives utilise the Phœnician juniper-tree as a substitute for the lignum vitæ in the construction of terrace walks, and extract from it a tar which is more valuable than that of the Aleppo pine.

GUM-TREE (*Acacia tortilis*).

This tree constitutes woods covering about 87,500 acres in the southern part of Tunis, between Gafsa and Mahrès.

A third of the wooding is composed of trees at a distance of about 50 ft. from each other. In the other two-thirds the distance between the trees is from 325 ft. and more.

The maximum height of the gum-tree is from about 33 to 50 ft. Its growth is very slow. The trunk is usually divided into two or three branches about 3 ft. from the soil, so that each tree gives but little utilisable timber. The total production of fancy wood does not exceed 200 cubic metres per year.

The perfect wood of the gum-tree is of a reddish brown of horny appearance, furrowed by a reticulated tissue of a greyish-brown tint, disposed in sinuous lines, interrupted and directed in a parallel direction to the circumference. These lines are often jumbled up together, so that it is difficult to give an account of the yearly layers. These delineations are formed by a vascular zone of porous wood, surrounded by large vessels visible to the naked eye. In the centre of the red wood, numerous openings of fine ducts are found.

The thickness of the sapwood is about a third of that of the perfect wood in ripe ages; the bottom is yellowish, sometimes greenish, the reticulated tissue is of a clearer greyish colour. The medullary rays are numerous, elongated, and thin.

The specific gravity of the wood of the gum-tree, taken from a sample whose age is estimated at about 150 years, is 0·99 in the dry state.

This wood is compact, hard, susceptible of taking a fine polish; it neither twists nor cracks. It can be employed for cabinetmaking.

Nettle-Tree.

This is found in Khroumirie, upon the Djebel-Zaghouan, in the mountains of the central chain and in the forests of Frechich. It generally comes in clusters in rather elevated rocky parts where the soil keeps fresh. It is also met with, in isolated places, in the midst of orchards of olive-trees.

The total area occupied by clusters of these trees in the Tunisian forests may be estimated at 750 acres, giving an annual production of 1200 cubic metres.

Mulberry-Tree.

The mulberry-tree is cultivated in the gardens of the whole of Tunis. It is a species of medium height, growing slowly and attaining a height of about 38 ft., with a circumference of about 10 ft.

The timber of this tree is yellow, becoming brown upon drying; the sap, which is not very abundant, is of a clear yellow colour; the medullary rays are rather compact. Each annual layer commences by a lighter zone of large ducts, which distinguish it from the preceding layer. It is hard, heavy, compact, and susceptible of receiving a beautiful polish. The natives make camel-saddles, wooden shoes, boxes, etc., from it.

Olive-Tree.

This variety is extensively found in Tunis. It is met with upon the littoral, in the mountains of the centre, and upon high plateaux; it is also cultivated in the oases of the south.

In the wild state it can, when its growth has not been impeded, acquire the dimensions of a tree of medium and even of the greatest height.

Olive-trees of 13 ft. in circumference by about 39 ft. in height are not rare in fertile plains and upon the banks of water-courses.

The main root (which is very strongly developed, tap-rooted, and running) of this species permits its vegetating in the poorest soils and under the driest of climates. The olive-tree is met with especially in calcareous and schistous soils, though it is rare in stony soils.

The growth of the olive-tree is slow, and its longevity considerable. Its timber is hard, compact, very heavy, homogeneous, without apparent sap, and of a yellowish colour.

In old trunks it takes in the centre a chamois tint, with veins of a deeper colour, varying from a ground colour to blackish brown. A beautiful polish can be given to it, and it can be "worked" with ease.

It is, moreover, an excellent firewood, which produces a charcoal of the first quality.

Wild olive-trees are small, giving but little oil.

Cultivated olives cover a large surface; they amount in number to about 170,000.

The most important plantations are found between Porto-Farina and Bizerte and at Zaghouan. Sahel, from Sousse as far south as Mehdia, the neighbourhood of Sfax and the isle of Djerba, is simply an immense orchard of olive-trees. The oases of the south contain large quantities of them, and the arid mountains of Matmata and Douïret still contain some of them in their valleys.

Elm.

The only variety of elm met with in Tunis is the sylvan elm. Like the ash, it is only found in exposed valleys. It is more abundant in Khroumirie than anywhere else, but it is again found, in isolated places, at Cape Bon, in the mountains of Zaghouan and Bargou.

The production does not exceed 1000 cubic metres per year.

Poplar.

The two varieties of poplars which grow spontaneously in Tunis are the white Dutch poplar, sometimes called *grisard*, and the black or Swiss poplar. They are only found, in isolated places, in exposed valleys, upon the banks of water-courses.

The production of poplars in the Regency cannot be estimated at less than 400 cubic metres per year. They are not exploited in a regular manner, on account of their state of dissemination and transportation difficulties.

Aleppo Pine.

The Aleppo pine is one of the most important varieties of the Tunisian forests. It covers, in the forest zone, all the calcareous mountains situated to the south of Medjerda, which still preserve some remains of the woodings. The superficial area covered by this variety is 450,000 acres.

It is a robust tree; it grows in all soils, even the driest, at all situations and altitudes. It is found from the level of the sea to the summit of the Djebel-Chanbi, the most elevated point of Tunis, at a height of 5200 ft.

The utility of the Aleppo pine in the Regency is enormous. It retains as woods districts which do not suit any other forest variety

and which the nature of the soil renders unfit for agricultural purposes.

Its adaptability has maintained it there, in spite of the most unfavourable natural conditions to vegetation. But as a rule it only constitutes thin plantations where the trees are badly grown, twisted, and mutilated; from place to place, however, beautiful thickets are found.

The actual treatment of forests of Aleppo pines consists in protecting the plantations against the delinquencies of the natives, thinning them out in order to favour their growth.

The wood of the Aleppo pine is of a yellowish-white colour. The natives use it extensively; they make from it the terraces of their houses and their cabins, as also the wood of ploughs, apparatuses for thrashing corn (called "Djarroucha"), shovels, weavers' looms, camel-saddles, etc.

The bark, of a silvery grey, is useful in the tannage of skins, etc. The tar is largely employed by the natives.

Maritime Pine.

This variety is only found in the north-west part of Khroumirie, upon the mountains situated between Tabarka and the Algerian frontier; it there covers a superficial area of about 7500 acres.

The groups of pines burnt in 1881, upon the entry of the French troops into Khroumirie, are to-day entirely reconstituted, being composed, in a large part, of young stocks, which dominate the reserves spared by the fire.

The timber of the maritime pine is reddish in the perfect state; the sap is white. This wood is rather hard and heavy, without softness, and intersected by resiniferous canals. It can be employed in the making of stakes, telegraph poles, etc.

Pistachio.

The Regency possesses four varieties of pistachios, namely—

Common pistachio.

Atlas pistachio.

Terebinth pistachio.

Mastic pistachio.

The Atlas and mastic pistachios are the principal ones.

The first is usually isolated, and is rarely met with in clusters. It is principally found in the Oued-Gharghaï plain and in warm plains and high plateaux.

Its wood has a greenish-white sap. In the perfect condition its

colour is brown, with green reflections and veins of a deeper colour passing to blackish brown. The medullary rays are numerous, short, and thin. Its annual layer includes two distinct zones, which make it easily recognisable; one contains large ducts, disposed in one or more rows; the other is in part formed by very fine ducts, grouped in considerable number, which form a clearer reticulated tissue.

The sapwood rots quickly, the perfect wood is hard, compact, heavy, and capable of receiving a beautiful polish. It can be employed for cabinetmaking and marquetry-work.

It is not yet employed by Europeans, though the natives utilise it for a variety of purposes.

The Atlas pistachio is a species which is valuable for the rewooding of the south of Tunis.

The second important variety, the *Mastic Pistachio*, is one of the dominating varieties of the underwoods of the Mediterranean region of Tunis. This tree grows in plains, upon the slopes, and in the lower parts of the mountains, and it is scarcely ever met with above an altitude of 1950 ft. All kinds of soil are adapted to its growth, but in fertile soils it may acquire dimensions which make it a veritable tree.

The timber of the mastic assumes, in the perfect condition, a rose colour inclining to yellow. It is heavy, hard, polishes well, and can be employed in cabinetmaking.

The sapwood, which is rather abundant, is white and very subject to become rotten; it can only be employed as firewood.

Lignum Vitæ.

The lignum vitæ is only found abundantly in Tunis in the Zaghouan group and in the mountains situated between Zaghouan and Cape Bon. It is generally met with in the form of a shrub or bush. However, on the Enfida estate certain of these trees grow to a height of from 13 to 16 ft.

The groups of lignum vitæ cover in Tunis an area of about 62,500 acres. Its growth is slow; the perfect wood, of a brownish-red colour, abounds with sap, which is white; it is heavy, hard, capable of receiving a beautiful polish, and highly esteemed for cabinetmaking.

It has already been said that this timber was in great demand by the ancients. Since their arrival in Northern Africa, the Romans knew how to appreciate the remarkable qualities of this tree, to which they gave the name of *Citrus*; they had such a consumption for it for furniture *de luxe*, that it afterwards became a rarity, and its price went up in fabulous

proportions. Hence, in the latter days of the Republic, this furniture became a veritable craze.

Cicero paid for a table of this wood £10,000 of our money. The Carthagus family possessed one which cost £14,000. The wood was generally used in veneers, but sometimes it was carved, and decorative cups and vases were made from it.

SECONDARY VARIETIES.

Other varieties of timber are found in Tunis which, though being of lesser interest, merit our attention.

These are: the Hawthorn, Strawberry-tree, Arborescent Furze, Lemon-tree, Maple, Fig-tree of Barbary, Holly, Jujube-tree, Myrtle, Buckthorn, Orange-tree, Philaria, Pear-tree, Plum-tree, Palma Christi, Willow, Sumac, Elder-tree, and Tamarisk.

A few details will now be given as to the principal ones.

BARBARY FIG-TREE.

This tree is cultivated throughout the whole of Tunis; it grows on all soils (even the most arid), provided they be not too damp.

In the plains of the south of Kairouan, its culture has taken a considerable extension. The plantations which are found near the Zaouïa of Sidi-Ameur-bou-Adjila occupy some hundreds of acres.

The fig of Barbary furnishes the natives with a portion of their nourishment at the end of the summer; Europeans can extract from it, by distillation, an alcohol which could be of use commercially.

The whole of the plantations of this cactus amounts to 85,000 acres over the Tunisian territory.

PHILARIA.

This is rather common in Tunis, especially upon the littoral; it is usually found in the form of a shrub, but in fertile soils and in fresh ravines it may attain the dimensions of a fourth-rate tree.

The wood of the philaria is yellowish, hard, compact, very homogeneous and tenacious. It will be found useful in carriage-building, lathe-work.

This tree lives to an old age, and grows easily from shoots.

SUMAC.

Tunis contains only two varieties of this: the five-leaved sumac and the oxyacanthus sumac.

The first-named inhabits the north, and is found in isolated places or in the plains and upon the hills. It is a thorny shrub, reaching a height of about 10 to 13 ft.

The oxyacanthus sumac is found in the south, where it is sometimes rather abundant. It is this which forms the green thickets seen on denuded mountains in the southern portion of the Regency.

The wood of the sumac is red in the centre; it is heavier than water, compact, and homogeneous. It does not attain sufficient dimensions to be employed in cabinetmaking, though very pretty work can be turned out of the lathe with it.

FIG. 105.—Dragon-Tree of the Island of Teneriffe.

The sumac, on account of its robust constitution and the property it possesses of growing in dry soil, is valuable for rewooding purposes.

TAMARISK.

The tamarisk of France and that of Europe is found throughout the whole of Tunis upon the banks of streams and in the sands.

The growth of these trees is rapid. At the age of twenty years they may attain a circumference of about 5 ft. The timber, of bad quality, cracks deeply.

In the south several varieties are found attaining rather large dimensions.

The principal utility of this variety is to serve as shelter from the winds, to bank in the streams, and to keep the sands from drifting.

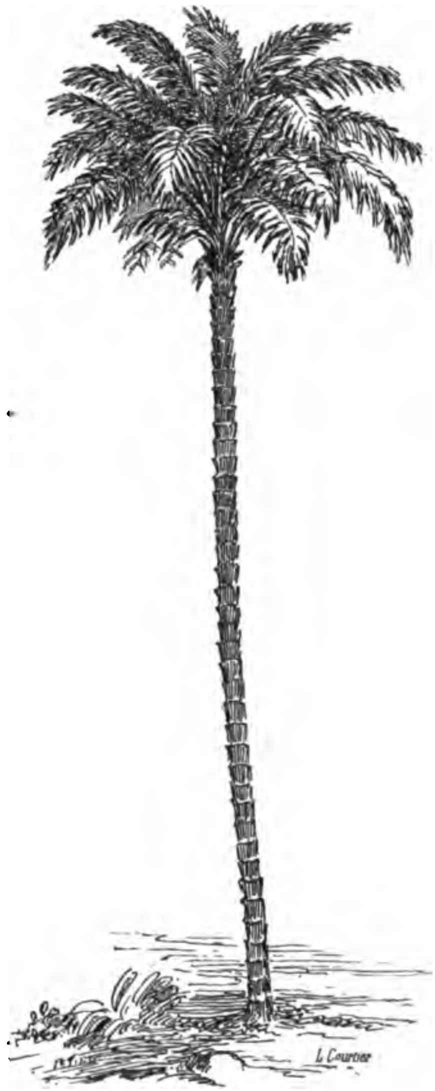

FIG. 106.—Palm-Tree.

SENEGAL.

Senegal, properly so called, does not produce a considerable quantity of timber, although a portion of its banks are covered with *Gonakiès* (*Acacia Adansonii*), very well adapted for shipbuilding. But it is not

the same in Casamance, where the forest resources are enormous. The principal varieties of this country are:

Khaya senegalensis, *cail cedra*: joinery, cabinetmaking.

Ériodendron anfractuosum, *bintaforo* or *benten*: light wood adapted for making canoes.

Detarium senegalense, *manbodo* or *détarr*: joinery and in fancy turnery trade.

Pterocarpus erinaceus, *kino* or *vène*: hard wood adapted for naval constructions.

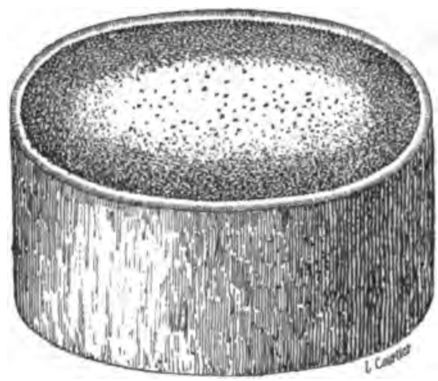

FIG. 107.—Cutting of Stem of a Palm-Tree.

Dialium nitidum, *kocyto* or *solum*: building wood.

Sterculia cordifolia, *danta*: shipbuilding.

Bauhinia reticulata, *ghighis*: carpentry wood (not very durable), employed for vessels.

The Navy can find amongst the woods of Senegal the best varieties, just as at Bissao, whence the Portuguese draw the largest part of their supplies for shipbuilding.

The Gabon Forests are richer still, but little cultivated. The sandal and ebony are alone regularly exported.

TIMBER OF REUNION.

Though considerably reduced by clearings, the resources of this island are still rather extensive. The surface covered by forests where valuable varieties grow in large quantities is estimated at 150,000 acres.

Besides the amount of timber for cask and cabinetmaking, the forests of the high lands of this colony furnish rather numerous varieties capable of being usefully employed in coachmaking.

Their resistance to blows, the fineness and polish of their grain,

which dispenses with the need of varnish, naturally adapt them for commerce.

The most esteemed and principal timbers are boxwood, ironwood, melanid ebony, filac, blue-heart, tacamahaca (*Callophyllum spurium*), etc.

TIMBER OF THE CAPE OF GOOD HOPE.

The country contains quite a crowd of useful varieties, the most important only of which, with their application, will be cited. They are:

Brabeium stellatifolium, *wilde amandelboom*: lathe, ornamentation joinery.

Buddleia salviæfolia, *saliehout*: carriage-building, agricultural implements.

Calodendron capense, *wilde kastanie*: agricultural implements.

Capparis albitrunca, *wintgatboom*: yokes and other domestic usages.

Cassine Maurocænia: yellow wood with brown veins, musical instruments.

Celastrus acuminatus, *zybast*: lathe, cabinetmaking, musical instruments.

Doryalis zyzyphoïdes: carriage-building, agricultural implements.

Élædendron croceum, *saffraanhout*: joinery, bark fit for tanning and dyeing.

Fagarastrum capense, *knobout*: domestic carriage implements.

Gardenia Thunbergia, *buffelsbal*: different implements.

Leucospermum conocarpum, *krenpelboom*: charcoal and heating purposes, excellent bark for tannage.

Olinia capensis, *hardpeer*: musical instruments, cabinetmaking.

Olea laurifolia, *black ironwood*: cabinetmaking.

Phoberos Mundtii, *klipdoorn*: building wood.

Podocarpus elongata: carpentry, joinery.

Rhamnus celtidifolia, *camdeboo*: bushelmaking.

Rhus viminalis: lathes and planks for the covering of houses; this wood is not attacked by insects.

Tarchoxantus camphoratus, *sirichout*: joinery and musical instruments.

CHAPTER IX.

ASIATIC TIMBER.

In the *northern region*, forests with sharp-edged leaves are formed by the *Siberian Larch*, *Dauric Larch*, *Siberian Pine*, *Cimbric Pine*, *Forest Pine*, etc. Isolated *White* and *Balsamic Poplars*, dwarf *Birches*, *Service-trees*, *Alders*, and *Willows* accompany them.

Humboldt assigns to the Ural forests the vegetation of a park, seeing that they offer alternately a mixture of sharp-edged and round-leaf trees, growing upon magnificent green swards.

CENTRAL REGION.

In this part of Asia the remarkable trees and shrubs are the *Elegant Palm-tree* known under the name of *Rhapis flobelliforme*, the *Japan Mulberry-tree*, *Odorous Olive-tree*, *Japanese Medlar* (*Mespilus japonica*), *Ginko bilbao* (holy tree surrounding the Pagoda), *Yew-trees*, *Juniper-trees*, *Cypress-trees*, *Lignum vitæ*, *Oaks*, and different varieties of *Nut-trees*, *Bay-trees*, and *Maples*.

SOUTHERN REGION.

Among the most abundant arborescent plants may be mentioned the *Bombax*, *Sapindus*, *Mimosa*, *Acacia*, *Gardenia*, *Diospyros ebenum* (the wood of which was celebrated in earliest antiquity), *Tectonia grandis* (a magnificent tree which furnishes a building timber with great resistant properties), *Isonandra gutta* (which produces gutta-percha, obtained by practised incisions in the trunk of this large tree), *Bay-trees* with aromatic bark, *Nutmeg-trees*, *Fig-trees*, *Palm-trees*, *Cocoa* and *Sago trees*, *Dragon-trees*, *Bamboo-tree*, *Tamarind-trees* (*Tamarindus indica*)—a delightful tree whose fruit contains a pulp of vinous odour and of sourish savour, etc. etc.

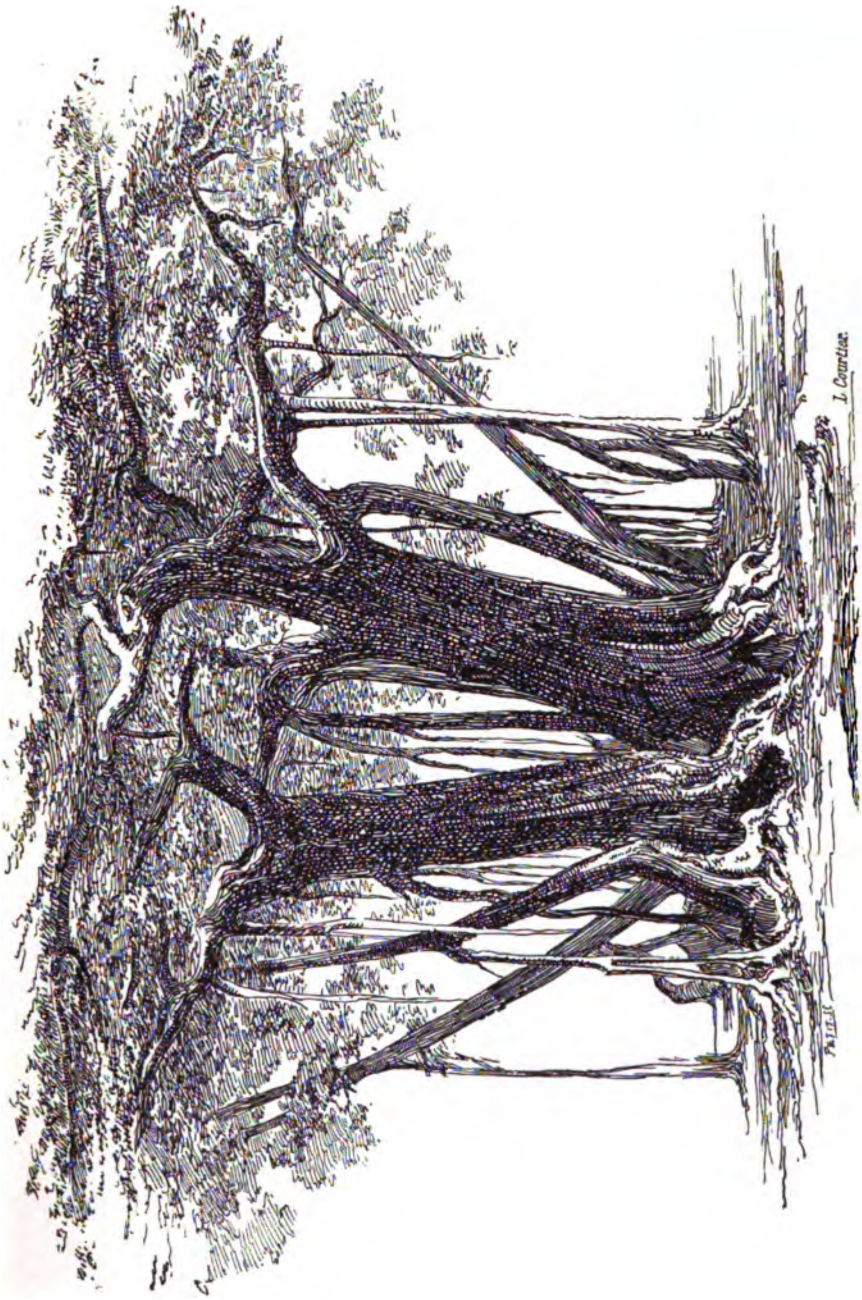

FIG. 108.—Pagoda Fig-Tree.

CHINA.

Some interesting trees are found in China, amongst which the following may be cited:—

The *Tallow-tree* (*Stillingia sebifera*), from which vegetable tallow (or fat) is extracted; then the tree which harbours the wax-making insect—this is a sort of ash found in abundance near canals and lakes in the Tche-Kiang. When the insects which produce the wax have accomplished their work upon the leaves of the tree, these leaves have the resemblance of being covered with flakes of snow. Afterwards comes the *Soap-tree* (*Cæsalpina*), the pulpous husks of which are largely used in the form of soap; the *Varnish-tree*, the produce of which is useful to the Chinese in the making of those lacquers which are so remarkable and renowned.

We may also mention the *Jujube-tree*, *Orange*, *Lemon*, *Cinnamon*, the *Knotted Anise-tree*, and the *Hemp Palm-tree* (*Cryptomeria Japonica*), the beauty of which is remarkable. The Chinese make mantles with large collars and enormous conical hats with the palm-leaves which are characteristic of it.

COCHIN-CHINA.

Here the forests are numerous, and their products are destined to play an important *rôle* in the export trade of this country. The province of Bien-hoa and Cambodge are the principal forest centres.

The timber of these countries is easily worked, of a very fine grain, but often fragile.

COLONIES OF THE NETHERLANDS.

In the tropics the timber has the advantage of growing in good conditions. The climate favours, after the felling of the trees, rapid exsiccation of the sap, thus obviating all danger of the wood becoming worm-eaten. It will therefore be readily understood of what great use this timber can be made in Europe.

The following are the most important:—

Arang (*ebony wood*).

It is indigenous to the Molucca Islands, and principally to Bouro, where the wood of the tree is as black as jet and of a texture more compact than anywhere else.

Behlo-Ham (*Dyospiros*).

This is employed in naval constructions for the wings of light ships, in order to maintain their equilibrium in a rough sea. In cabinetmaking it may be substituted for ebony wood.

Kojoe Besi (*ironwood*).

This is very useful in lining ship timbers.

Djati Kapoor (*Tectonia grandis*).

The "Teck" or "Djati" grows indigenously in the vast forests of the high central and eastern regions of Java. It is known that it is not possible to preserve it from the ravages of the cappanus.

Masi Meira (*Nania vera*).

One of the best woods for naval constructions, as it resists attacks of the cappanus; neither is it changed by acids.

Tanœu (*ironwood*).

Its specific weight is equal to that of the ebony; it is employed in joinery.

JAPAN.

This empire has a rich collection of very useful timbers, with regard to which some details will be given. They are principally:

Trees with Caducous Leaves.

Abemaki (*Quercus variabilis*).

This attains about 8 ft. in circumference and about 60 ft. in height. It is employed for fuel. The cork of its bark is useful in the making of cork-stoppers.

Aburagiri (*Elæoccoca cordata*).

Circumference about 3 ft. 6 in., and height about 30 ft.; it is useful in the making of boxes, wooden shoes, etc. Its bark is used for dyeing purposes.

Akashide (*Carpinus Japonica*).

Circumference about 3 ft. 3 in., and height about 40 ft.; it is useful in the making of agricultural implements and for firewood.

Akiniré (*Ulmus parvifolia*).

Circumference about 3 ft. 3 in., and height about 50 ft.; used for the making of furniture, etc.

Asada (*Ostrya virginica*).

Circumference about 5 ft., and height about 65 ft.; principally employed in the making of furniture.

Buna (*Fagus sylvatica*).

Circumference about 10 ft., and height about 50 ft.; it is employed in turnery work, agricultural implements, etc.

Ego (*Styrax Japonicum*).

Circumference about 3 ft. 3 in., and height about 20 ft.; it is in demand for making of tops, etc.

Hannoki (*Alnus maritima*).

Circumference about 3 ft. 3 in., with a height of about 40 ft.; charcoal for cannon-powder is made from it.

FIG. 109. Sophora of Japan.

Hoonoki (*Magnolia hypoleuca*).

Circumference about 8 ft., with a height of about 50 ft.; it is used in the making of tables, planks for cutting up, wooden shoes, pencils, and charcoal.

Katsura (*Cercidiphyllum Japonicum*).

Circumference about 10 ft., and height about 80 ft.; it is used in the building of houses and in the making of boxes and turned objects.

Mame-Gaki (*Diospyroslotus*).

Circumference about 5 ft., and height about 40 ft.; it is useful in the making of small objects, uprights of steps, and turnery work. "Shibu" (a sort of astringent varnish) is extracted from its fruits.

Nigaki (*Picrasma allantoïdes*).

Circumference about 5 ft., and height about 50 ft.; it is employed in the making of agricultural implements. Its bark is used as an insecticide.

Saruta (*Stuartia monadelpha*).

Circumference about 8 ft., and height about 40 ft.; it is employed in Toko for the manufacture of tools.

Tochi (*Æsculus turbinata*).

Circumference about 6½ ft., and height about 20 ft.; it is used in the building of houses and turned varnish work. It is also employed in the making of boxes, etc.

Evergreen Trees.

Of these trees the following may be mentioned:—

Akagashi (*Quercus acuta*).

Asebi (*Andromeda Japonica*).

Biwa (*Photinia Japonica*).

Inutsugue (*Ilex crenata*).

Inusoki (*Distilium racemosum*).

Kagonocki (*Actinodaphne lancifolia*).

Kusunoki (*Cinnamomum camphora*).

Mokkaku (*Ternstrœmia Japonica*).

Nikkei (*Cinnamomum Laurerii*).

Shii (*Quercus cuspidata*).

Tobera (*Pittosporum tobira*).

Tsuge (*Buxus Japonica*).

Ubame-gashi (*Quercus phyllireoïdes*).

All these woods serve in general in the building of ships and houses; some of them are employed in the making of small furniture and turnery work.

KINGDOM OF SIAM.

The vegetable products of this country are very numerous, thanks to its being in the vicinity of the tropics and to the periodical rains which water the soil.

Upon the frontiers of the Birman Empire vast forests of teak are found. When the rough wood is dry enough, rafts are made from it, and it is taken in this condition by water to Bangkok, where it is usually sawn into planks.

There exist, besides, in the interior of the kingdom, other varieties of timber, amongst which that known under the name of *Takieng*, which can rival with the teak, possessing the valuable quality of being easily bent.

In different districts, and particularly upon the eastern side of the Gulf of Siam, the species of pine grows from which excellent resin is produced.

Dye woods are not rare, and the deal especially is exported, which grows spontaneously in the regions of the North and upon the hills of the Indian province of Tenasserim.

We may likewise mention the fig-tree, the middle of which has a beautiful yellowish colour, which is very brilliant, and renders the wood of use in cabinetmaking; the *Morinda citrifolia*, the roots of which provide the natives with a scarlet-red colour; and, lastly, the mangrove-tree, the *Mangle rhyzophora*, the bark of which is employed for tannage purposes.

CHAPTER X.

AMERICAN TIMBER.

NORTH AMERICA.

THE polar vegetation of North America greatly resembles that of Europe and Asia. In the intense cold the *Willow*, *Birch*, and *Poplar* grow as stunted shrubs.

Among the most important arborescent varieties may be mentioned the numerous varieties of *Pine*, *Fir*, *Larch*, *Lignum vitæ*, *Juniper*, a large number of *Willows* and *Oaks* of different sorts; *Beech*, *Chestnut*, *Yoke-elm*, *Birch*, *Poplar*, *Elm*, *Ash*, *Platane*, etc., and *Maple*, *Lime*, and *Nut*.

The same species are found in the southern region, and the *Palm-trees* commence to appear, then the *Tulip*, *Robinia*, and magnificent *Magnolias*.

SOUTH AMERICA.

If one ascends the Andes by degrees, he will first meet the *Ceroxylon andicola*, the tallest of all the palm-trees, attaining a height of 195 ft., and producing a wax which exudes from its leaves and especially from the base of their petioles; and then the *Willow* and *Humboldt Oak*, *Hollies*, *Andromedas*, etc.

In the vicinity of Caracas, the *Banana*, *Orange*, *Coffee*, *Apple*, and *Apricot trees* are found, as also two valuable trees, the *Theobroma cacao* and *Cow-tree*. The first produces seeds which, grilled and sweetened, are useful in the making of chocolate.

M. de Humboldt supplies us with the following information with regard to the *Cow-tree*:—

"This beautiful tree," says the illustrious *savant*, "resembles the *Caimitier*. The fruit is not very fleshy, and contains one or sometimes two nuts. When incisions are made in the trunk, a rather thick viscid milk, with no acidity, and exhaling a very agreeable odour of balm, is gathered in abundance.

"The negroes working in plantations drink it and soak cassava bread in it."

As will be seen further on, Brazil has a luxuriant vegetation. The forests contain an abundance of wood which is very useful for dyeing, carpentry, and cabinetmaking (rosewood, ironwood, violet ebony).

The aspect of the Brazilian forests varies according to the nature of the soil and of the streams running through them.

If these forests have no water-courses or springs, the dryness arrests the vegetation, which becomes intermittent, as in our climates. But if, on the other hand, it is uninterruptedly excited by the two principal agents, damp and heat, the vegetation of the virgin forests is then maintained in continual activity.

Leaving Brazil, we find in the little known forests of Paraguay ligneous products and the *Maté* of South America, which represents the China *tea-tree.*

Lastly, thick forests cover the mountains in Tierra del Fuego, where they are sheltered from the wind up to a height of about 1625 ft. The *Birch-leaf Beech* predominates there, as do likewise the *Antarctic Beech, Forster Beech,* etc.

ARGENTINE REPUBLIC.

The quebracho (the most interesting tree of this country) is the only one which will be noticed.

The *Quebracho Colorado* has been classed as an *Anacardiaceæ* under the name of *Loxopterigium Lorentii.* Its only ally is the species *Loxopterigium Sagotii hoki,* indigenous to French Guiana.

It furnishes a timber of reddish aspect and of exceptional hardness, whence its name "quebracho" (*Quiebra hacha*), very straight, without knots, having good dimensions in bulk, rarely exceeding 26 ft. in length. It offers great resistance, and is of almost unlimited durability. Its specific gravity is 1·35; for very old wood it falls to 1·27. It is owing to the absence of pores, stopped up by incrustated matter, that it owes its great specific weight.

	Per cent. of Tannin.
Its bark contains from	6 to 8
The sap " "	3 " 4
The heart " "	19 " 22

This tree has the peculiar phenomenon of producing tannin in its bark, like the oak chestnut and so many other trees; and, like them, it also contains some in its sapwood, and moreover of storing it, in a

concentrated state, in considerable quantity in the whole of the central part of the wood. At the same time there is produced in the liber of the bark, a gum having the characteristics of gum-arabic, which can be gathered by making incisions in the bark.

This gum also becomes concentrated in the centre, and is charged in its passage with all the tannin produced, so that it is *tannin gum* which is stored in the central part of the wood. As the heart of the quebracho represents two-thirds, and often three-quarters, of the total quantity of wood, the amount of tannin contained in this variety is considerable. This gum is a remarkably useful companion to the tannin; it coats it like varnish, and prevents it from deterioration.

The tanning and other industries are beginning to find in this tannin a valuable agent.

Moreover, dyers employ it as a colouring matter; for this tannin, the colour of which is brownish red, is coloured bright red by acids, and takes tints varying from red to black, with certain bases, such, for example, as the oxide of iron. The gum may at the same time serve to fix the colours upon the cotton fibres.

The extraction being able to be made by water is most economical. For a long time past the local tanners have employed the wood, in the state of coarse sawdust, for the tannage of leathers. As the effect of a propitious climate and of the energetic action of this tannin, bullock-hides are tanned in seven to eight months, giving leathers whose impermeability renders them of admirable quality.

Quebracho wood has the valuable quality of being preserved indefinitely in the soil and in soft or salt water.

Coasting vessels of the Parana and Uraguay rivers built of this wood last a long time.

It is moreover employed, to the exclusion of all other wood, as sleepers by the State and by the railway companies of the Argentine Republic. The net price of the quebracho cross-piece is higher than that of the oak, but the durability is a recompense for the increased cost.

BRAZIL.

The woods and forests of Brazil, spread in compact and incalculable groups in these countries which occupy a fifth of the surface of the globe and more than three-sevenths of South America, are especially characteristic to the south of Rio de Janeiro, in the provinces of San Paulo, Parana, Santa Catharina, Rio Grande do Sol; to the north in the provinces of Bahia, Ceara, Maranhao, Para, and Amazon.

As a general rule, Brazilian timber is admirably adapted for ship-building and house-carpentry. It provides commerce with the richest and best varieties; to medicine, dyeing, to the arts the most important resources; and lastly, is the source of very nutritious products consumed upon the spot or exported.

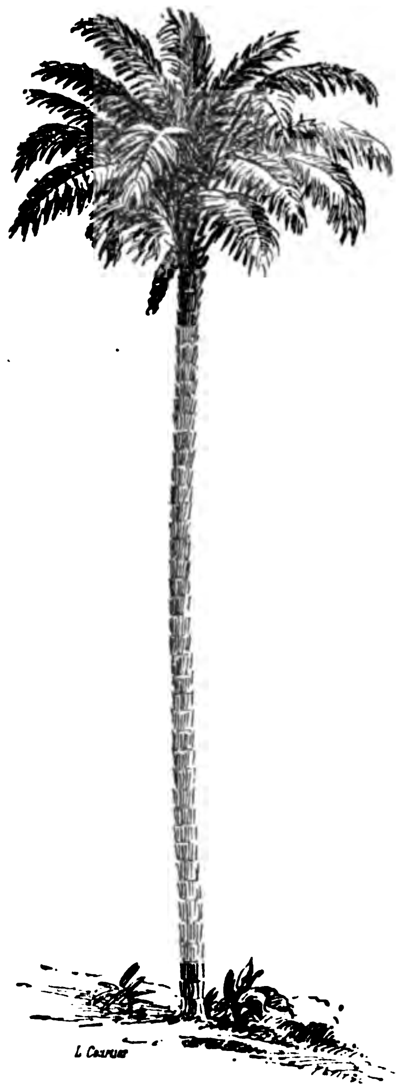

FIG. 110.—Mauritia flexuosa.

The region where this marvellous flora attains its highest point of development occupies the immense basin of the Amazons.

Upon the lakes of this superb region the *Victoria regia* is displayed; on river-banks the cacao and caoutchouc form imposing groups; further

on, the copaiba, rosewood, and other exquisite varieties are extended in vast forests.

At the time of the freshets, the floods carry away considerable quantities of this valuable wood, which only requires the trouble of gathering.

An abridged enumeration of the principal Brazilian woods, with a description of their properties, will now be given.

Almecega (*Icica*).

Trunk about 33 ft. high, with a diameter of about 3 ft. 3 in. The wood is very resinous, and this resin is in demand in medicine and the arts. It grows in abundance in the provinces situated to the north of Rio de Janeiro.

Andiroba (*Carapa Guyanensis*).

This is a tree of more than 42 ft. in height, having a diameter exceeding 6½ ft. It grows in the northern provinces; the wood is employed in building; the bark and seeds, which are oleaginous, are also used in commerce and medicine.

Arueira do Campo (*Schimus antarthrilua*).

This is a beautiful tree. From its bark, which is strongly astringent, a febrifuge principle is extracted. The timber, which is rather resinous, is extensively employed: it is one of the best of Brazil.

Bacupary (*Platonia insignis*).

This is a tall tree, the straight trunk of which attains a height of 65 ft. and 6½ ft. in diameter. It grows in the provinces of Maranhao, Para, and Amazons. The timber, which is hard and a little elastic, is employed in civil and naval buildings. The fruit of this beautiful tree is large and comestible; excellent sweatmeats are obtained from it.

Becuiba (*Myristica Bicuiba*).

This is a high tree, adapted for buildings and joinery; from the kernel of the fruit a fatty matter is extracted, which is used in skin diseases.

Cajueiro Bravo (*Curatella Cambaïba*).

This is a tree of ordinary dimensions, whose wood has an undulated grain, like that of the Catucahem, and this property makes it very useful in joinery-work and building in general. The leaves are rough to the touch, and are used for polishing delicate joinery-work. It abounds in the plains of the interior and northern provinces.

Carnauba (*Copaïfera cerifera*).

This is a very renowned palm-tree, giving by itself the most remarkable collection of products which a plant can furnish. The fruit and the nut give a very healthy food and a nutritive beverage. The

leaves are covered by a pulverulent, dry matter which furnishes wax; they also serve to make impermeable roofs. Transformed into threads, they are employed in the manufacture of cords, strings, harnesses, hats, mats, brooms, straw-mats, and paper. The timber is very valuable; it is very hard, elastic, of a reddish-yellow colour, with a black vein, fit for building purposes and joinery and cabinetmaking-work.

Castanheiro (*Bertholletia excelsa*).

This is one of the tallest trees in Brazil. Its timber is compact and very hard, and is largely employed in building. Its bark produces an excellent oakum (adapted for the calking of vessels), and a valuable oil. This species grows in the valley of the Amazon.

Cedro (*Cedrela Brasiliensis*).

This is a beautiful tree, of remarkable height. The trunk often attains a diameter of about 13 ft. It is met with in all the provinces to the north of Rio de Janeiro, and especially in the Amazon valley, where it reaches the largest dimensions.

Cumary (*Aydendron Cuyumary*).

This is a tall tree. Its timber is employed in civil and naval constructions, as well as in joinery. Its seeds, which are odorous, are used by pharmacy.

Embira (*Xylopia*).

This is a medium-sized tree. The wood is hard, very strong, and fit for building purposes. The fibres of the bark are largely employed in the making of cords and coarse tissues. This tree is frequent in almost all the provinces of Brazil.

Genipa peiro (*Genipa Brasiliensis*).

This is a rather tall tree, which is utilised for the making of lathe-work, wheels, and pulleys. Its wood is compact and very hard, and, owing to its properties, it is largely employed in buildings. Its fruit is edible. This tree is met with in all the Brazilian provinces.

Iri (*Astrocarium Ayri*).

This is a rather tall palm-tree. Its wood is extremely rigid, and is employed in the making of different objects of marquetry and joinery. A vinous juice is extracted from the trunk, which is appreciated in the interior of Brazil, where drought is very frequent. The fruit of this useful palm-tree is agreeable and very nourishing.

Jacaranda (*Machærium*).

This is a tall tree; the timber is usually of a blackish-red tint; it is one of the hardest and most compact known, and is generally in great demand for building purposes, joinery, marquetry, and lathe-work. It is the *Violet Ebony*. Under this name several varieties of trees are

known, some of which belong neither to this genus nor to this family. They inhabit the provinces situated to the north of Rio de Janeiro.

Jacariuba (*Calopyllum Brasiliense*).

This is a tree of immense height, the trunk of which is often about 10 ft. in diameter. It is made use of in building and for joinery-work. A yellowish balm is extracted from it, of aromatic odour and of harsh and bitter savour.

Jaqueira (*Artocarpus integrifolia*).

This is a tree having large dimensions, whose diameter often exceeds 3 ft. 3. in. Its timber is hard, of a beautiful yellowish tint, adapted for civil and naval constructions, being specially employed in coasting vessels. The fruit is sometimes 1½ ft. long, and contains farinaceous seeds enveloped in a thick pulp, which is soft and highly perfumed.

The Jaqueira is not a native of Brazil, though it grows there in abundance.

Jutaby (*Hymenæa*).

The height of this tree varies from about 50 ft. to 80 ft.; its diameter often attains 6½ ft. The timber, which is very hard and compact, is highly prized; it is not attacked by worms. Beautiful planks are made from it. These are the trees, particularly the *açu* and *cica* varieties, which furnish the balm-resin known in commerce under the name of gum or copal resin. They are found in almost all the Brazilian provinces.

Mangabeira (*Hancornia speciosa*).

The wood is compact and hard. The juice which is extracted from it, when it is in a coagulated condition, has all the properties of caoutchouc. This tree grows in the interior and in the northern provinces.

Massaranduba (*Mimusops elata*).

This tree is about 80 ft. high, and its trunk has a diameter of about 10 ft. It furnishes, by incision of the trunk, a milky juice of a white colour, rather sweet, savoury, and nourishing, which is used in this state as milk, even with tea or coffee. It becomes coagulated at the end of twenty-four hours into a white elastic mass, similar to gutta-percha; the bark is very rich in tannin. The timber, which is one of the hardest, is employed in civil and naval constructions and in joinery; its milk is utilised in the household, and the bark in dyeing. This tree, which is one of the most valuable known, grows in the provinces situated to the north of Rio de Janeiro.

Pao d'arco (*Tecoma speciosa*).

This is a high tree, attaining a height of about 100 ft.; the trunk is often more than 10 ft. in diameter. The wood is very hard, compact, and elastic. It is highly esteemed, and is found in almost all the provinces.

Pao precioso (*Mespilodaphne pretiosa*).

This is a tree of average height. The wood is very hard, compact, and has a beautiful grain; it is used for building purposes. It grows preferably in the dry soil of the Amazon province. The bark, seeds, and wood are odorous. It is extensively used in perfumery.

Pao santo (*Cumbeira*).

Of average height, the wood of this tree is black, very hard, and of great density. It is considered as one of the best of the north of Brazil.

Pao violeta (*Machærium violaceum*).

This is a rather tall tree, whose trunk is rather thick. Its timber is hard, compact, and of a beautiful colour. It is employed in furniture-making and for delicate cabinetmaking purposes. It is a native of the Amazon Valley.

Seringueiro (*Syphonia elastica*).

This tree has a height varying from 33 ft. to 66 ft., and the trunk often attains a diameter of 6½ ft. It furnishes, by incision of the trunk, a large quantity of gum-resin, which, upon coagulating, becomes the elastic substance well known under the name of *caoutchouc* or elastic gum, so universally employed. The wood is only of mediocre quality. It is the same tree as the *Hevera Guyanensis*.

Umiry (*Humirium floribundum*).

This is a tall tree, whose wood is employed for buildings. There is distilled from the bark and wood a balm of yellowish colour, limpid, and of an agreeable odour, employed in medicine as Peru balsam.

FRENCH GUIANA.

This colony is one of the richest countries of the world in building wood, transport of which is facilitated by the numerous water-courses. The principal varieties met with in the country may be classed as follows:—

ARTOCARPEÆ.

Bagassa Guyanensis.

Bagasse: tree of large dimensions, very straight and excellent for flooring. Weight: dry, 0·745; green, 1·130; strength, 215 kilos.

Piratinera Guyanensis.

In England this is known as "Letter wood," or speckled-letter wood. It is one of the most beautiful woods known; but the small dimensions of the speckled part and its high price limit its employment to marquetry and to small furniture *de luxe*.

The interior of Guiana contains a large quantity of these trees.

Specific weight: dry, 1·049; green, 1·162; strength of resistance to breaking, 340 kilos.

BIGNOMACEÆ.

Tecoma leucoxylon (*Green Ebony*).

This is the Quirapaïba of Brazil; three varieties of it are found at Guiana: the green, grey, and black, largely distributed in the forests. Their grain is fine and serrated; on account of their durability, they are highly in demand for building purposes. The green ebony of Guiana changes greatly as a result of long exposure to air, and is scarcely recognisable at the end of some years.

Specific weight: dry, 1·211; green, 1·220; strength, 481 kilos.

BURSERACEÆ.

Icica altissima (*Bagasse, or White Cedar*).

Wood of large dimensions, of excellent quality for cabinetmaking and for canoes. It is often difficult to procure it, for this tree is considered fetich by the indigenous tribes.

Specific weight: dry, 0·842; green, 1·036; strength, 226 kilos.

CEDRELACEÆ.

Cedrela Guyanensis (*Female Acajou*).

This is a tree of large dimensions, common at Mana and in Oyapok. It is good, especially for the interior of household furniture, as termites (white ants) do not attack it. The Indians carry every year large quantities of it to Cayenne. The bark is used as a bitter tonic.

Specific weight: dry, 0·349; green, 0·894; strength, 80 kilos.

CHRYSOBALANEÆ.

Acioa Guyanensis.

This is the "Water Copie" of Surinam. Close-grained wood, of good quality, very well adapted for railway work and for shipbuilding, for which it requires to be lined with copper. In spite of the disagreeable odour which it exudes, it is employed exclusively at Surinam in the building of houses. Its fruit contains an almond which is agreeable to the taste, and which gives an oil analogous in savour and fluidity to that of filberts. The ash of the wood enters into the composition of Indian potteries.

Specific weight: dry, 0·819; green, 1·063; strength, 179 kilos.

EUPHORBIACEÆ.

Hevea Guyanensis (*Hévé*) (Caoutchouc).

This is a tree with white coarse-grained wood, furnishing the caoutchouc of commerce. The Galibis eat the seeds.

Specific weight: dry, 1·038; green, 1·175; strength, 317 kilos.

HUMIRIACEÆ.

Myriodendrum amplexicaule (*Red or Incense Wood*).

This is a large tree, whose timber is frequently employed in buildings, providing the ribs for naval constructions. It gives the balm-resin *houmiri*.

Specific weight: dry, 0·662; green, 0·856; strength, 186 kilos.

Incertæ sedis (*Bitter Wood*).

This is useful for the making of planks, beams, railway sleepers, pins, etc.

Specific weight: dry, 0·769; green, 1·142; strength, 170 kilos.

Panapi.

This is largely used in carpentry; a red dye-stuff is extracted from it.

Red Ebony.

Good wood for building and cabinetmaking.

Mincouin.

Hard, compact, and incorruptible wood, good for railway sleepers. The boiled shavings give a black dye, which takes very well on cotton.

Specific weight: dry, 0·952; green, 1·135; resisting strength, 347 kilos.

LAURINEÆ.

Aniba Guyanensis.

Yellow cedar; employed in making of planks.

Specific weight: dry, 0·489; green, 0·606, resisting strength, 145 kilos.

Licaria.

Male rosewood, hard, compact, and incorruptible, not attacked by cappanus.

Specific weight: dry, 1·108; green, 1·225; strength, 361 kilos.

Laurus.

Cinnamon wood common to Guiana, heavy, of cinnamon-like odour, not attacked by insects, of rather large dimension, employed for railway sleepers and naval constructions.

Specific weight: dry, 0·801; green, 1·070; strength, 184 kilos.

Nectandra pisi.

Black cedar. This is a rather common wood, of large dimensions,

valuable for building purposes; it is incorruptible and resists insects, supple, firm, and light; it is appreciated for the side-planks of ships. In working with it copper nails should be used, as the special acid which it contains quickly eats away iron.

Specific weight: dry, 0·648; green, 0·818; strength, 159 kilos.

LEGUMINOUS.

Dipterix odorata.

Guaiacum of Cayenne. This is a tree of large dimensions, common in Guiana. Hard and solid wood, eminently durable and better capable of withstanding than any other strong pressure; its bean serves to flavour snuff. The Galibis make necklaces from these beans; the bark and wood are employed as a substitute for medicinal guaiacum. The leaves contain an aromatic oil.

Specific weight: dry, 1·153; green, 1·213; strength, 385 kilos.

Hymenæa courbaril.

This tree abounds in Guiana. Its trunk attains, without ramification, a height of 78 ft., with a diameter of from 6½ to 10 ft. On becoming old it assumes a mahogany colour, and provides beautiful curves for use in naval constructions. The Indians make canoes with its bark, and they eat the farinaceous pulp which encloses the seed.

Specific weight: dry, 0·904; green, 1·191; strength, 333 kilos.

Dicorenia paraensis (*Angelica*).

This timber is of first quality and of large dimensions, standing in high estimation, especially for naval constructions. Cappanus and insects do not attack it. It is also employed in joinery. This timber is common throughout the whole of Guiana, and provides planks with a length of from 50 ft. to 65 ft. Three varieties are known: black, red, and white

Specific weight: dry, 0·746; green, 0·851; strength, 215 kilos.

Copaïfera bracteata (*Violet Wood, Amaranth*).

This tree is of large dimensions, and very common in Guiana; it is adapted to every kind of construction. Furniture is made from it whose colour varies from brownish to blackish purple, and even black. Its timber, whose durability, elasticity, and solidity will stand every test, is employed in English Colonies in the making of artillery platforms.

Specific weight: dry, 0·771; green, 0·967; strength, 231 kilos.

Andira aubletii (*Wacapou, Ear of Corn*).

This timber is incorruptible, and not attacked by insects; it is renowned for its strength and durability, excellent for naval constructions, cabinetmaking, and railway sleepers. It is rather common in Guiana.

Specific weight: dry, 0·900; green, 1·113; strength, 304 kilos.

Robinia panacoco.

This tree often reaches a height of 50 ft., with a diameter of 8 ft. Its timber, which is black, with white sapwood, is very compact and excellent for cabinetmaking. It is incorruptible, and is useful for making palisades. The bark is employed in making sudorific medicinal drinks.

Specific weight: dry, 1·181; green, 1·231; strength, 400 kilos.

Bocoa Pouacensis (*Boco or Coco Wood*).

The heart is blackish brown, the sapwood clear yellow. The wood is hard, compact, of large dimensions, rather common, and formerly highly esteemed in France for cabinetmaking *de luxe*.

Specific weight: dry, 1·208; green, 1·234; strength, 402 kilos.

MELIACEÆ.

Xylocarpus carapa (*Red Carapa*).

The ease with which this wood splits is the reason of its being employed in the making of laths. The Carapa furnishes a thick and bitter oil, with which the natives cover their bodies to keep off the insects, and which is also useful in soapmaking. Its bark is commended as a febrifuge. It is very common in the Cachipour district.

Specific weight: dry, 0·659; green, 0·882.

PALM-TREES.

Guiana contains a number of varieties of these, amongst which may be mentioned: the *Cocoa-tree, Macoupi, Macaw Palm, Maripa, Mocaya, Comon, Ronn, Bamboo Palm*, and the *Date-tree.*

RHIZOPHOREÆ.

Rhizophora mangle (*Red Mangrove-tree*).

This tree covers, with the white mangrove, all the shores of Guiana. Its wood is largely employed for naval constructions, and its bark is useful in tanning.

Specific weight: dry, 1·017; green, 1·218; strength, 297 kilos.

SAPOTACEÆ.

Mimusops Balata (*Red or Bleeding Balata, Galibis Balata*).

This is a very large tree, excellent for thole-pins and compressed wood; it is common in the virgin forests; the fruit is edible. The sap gives a sort of gutta-percha which is highly esteemed, not brittle in cold weather, and especially adapted for covering submarine electric cables, as likewise for the making of surgical instruments.

Specific weight: dry, 1·109; green, 1·232; strength, 353 kilos.

Sideroxylon (*Ironwood*).

The name "Ironwood" is also given in the colony to the *Mouriria*, a tree having very hard wood, though small dimensions. Different Sapotaceæ also have the name of small-leaved "Balata" and mountain Balata.

SIMARUBACEÆ.

Simaruba officinalis.

Wood similar to the pine in quality; easily workable.

Quassia amara.

Cayenne quinine; tender and light wood, not attacked by insects.

VERBENACEÆ.

Avicennia nitida (*White Mangrove*).

Tall and straight timber, employed for small masts, though a little heavy; the heart of the old trunk is excellent for piles in briny mud.

Specific weight: dry, 0·768; green, 1·104; strength, 146 kilos.

ZYGOPHYLLEÆ.

Green "Brimstoned" Ebony.

This wood contains principles curious from a scientific point of view. One of these principles is colourless and crystalline; another is of a beautiful golden yellow in the crystallised state. This wood is employed in pharmacy in America.

MEXICO.

The cultivation of immense Mexican forests, stocked with the most various and richest varieties, has up to the present time been conducted under deplorable conditions.

The fellings, made at random—without care and without rewooding, without previous selection of the trees—have resulted in an enormous wasting away of one of the most considerable sources of wealth of this country.

Around the centres of population, notably in the vicinity of the capital, which was formerly surrounded by secular forests, the denudation of trees has been complete, and at present, in the Mexico valley, only rare clusters of trees are found. It is only in the more distant regions that forests are found, now confined to the slopes of the mountains surrounding the large valley.

But, in spite of this large waste, there still remains a forest wealth capable of exploitation, compared with which that portion already exploited is, in reality, of small account.

Mexico contains a very large quantity of different varieties; five hundred names of different timber could be cited, all having some commercial interest. It is not proposed to enter upon such an enumeration, which would, moreover, only be, in part, a recapitulation of the numerous descriptions already given.

TIMBER OF MARTINIQUE.

Martinique possesses an abundance of timber for building purposes, cabinetmaking, and dyeing, but lacks the means of communication, and the steepness of wooded places makes exploitation difficult.

This colony has about 50,000 acres of forests, comprising the most various varieties, the principal of which will be given.

AMARYLLIDEÆ.

Agave Americana.

Tinder wood; the flower-stalk serves in the setting of razors, replacing cork for a variety of usages.

AMYGDALEÆ.

Prunus sphœrocarpa.

Cabinetmaking wood, employed for small furniture. Very common in the communes of St. Luce and of the River Pilote, as well as in the woods of the centre of the island.

ANACARDIACEÆ.

Western Anacardium.

Fruity acajou, common throughout the isle; the fruit is edible.

APOCYNEÆ.

Plumeria alba.—*White plumeria.*

The timber of this tree is well adapted to marquetry-work.

Nerium oleander.—*Rose-laurel*—common.

ARTOCARPEÆ.

Artocarpus incisa.—*Pine-tree.*

This is a tall tree, whose wood (which is yellow) can be polished beautifully, and is highly esteemed in cabinetmaking. Its fruit, roasted or cooked in the oven, constitutes the principal nourishment of the

Oceanians. It is an incorruptible variety, and very common in the island.

AURANTIACEÆ.

Citrus aurantium.—*Orange-tree.*

This is a very common cabinetmaking wood.

BIGNONIACEÆ.

Bignonia pentaphylla.—*Pear-tree.*

This is a cabinetmaking timber, employed for furniture and in demand for carriage-work. It is very common.

Bignonia.—*Brownish-green Ebony.*

Cabinetmaking wood; the tree which produces it is rather common in the island, except in some communes of the south.

Catalpa longissima.—*Antilles Oak.*

Its qualities are similar to those of the European oak.

BURSERACEÆ.

Bursera balsamifera.—*Gum-tree.*

Is useful in the making of canoes and oars.

CEDRELACEÆ.

Cedrela odorata.—*Female Acajou.*

This is an excellent wood for cabinetmaking, and the bark is used as a febrifuge. It is rather common in the communes of Prêcheur, of the River Pilote, and of Lamentin.

CLUSIACEÆ.

Colophyllum calaba.—*Galba.*

This is a beautiful resinous tree, adapted for masts and carriage-work. An abundant oil can be produced from the seed, which is useful both in painting and varnishing. It is very common in the island.

Mammea Americana.—*Native Apricot-tree.*

This is a fruit-tree about 50 ft. high; its wood is white and gummy, and easily cracks; it provides staves and girders. The flowers serve in the making of liqueurs.

COMBRETACEÆ.

Terminalia catappa.—*Native Almond-tree.*

White and very hard wood; a rather tall tree. The almonds are edible, giving an oil which does not go rancid. It is very common upon

the coast, especially in the neighbourhood of the towns. This tree has been introduced from the Indies to the Antilles.

CONIFEREÆ.

Thuja orientalis.

This is rather numerous in cemeteries. In the country its wood is not used.

CORDIACEÆ.

Cordia gerascanthus.—*Cypress Wood.*

This is highly esteemed for cabinetmaking, and is extensive throughout the colony.

EBENACEÆ.

Diospyros mabolo.—*Mabolo.*

Incorruptible wood; there are a large number of representatives scattered throughout the country.

EUPHORBIACEÆ.

Hyppomane mancinella.—*Mancanilla.*

This wood will take a beautiful polish, but it is little used on account of the venomous juices which it contains. It is, however, excellent for cabinetmaking. This tree is very common in the south of the island, where, however, good specimens are rather rare. The sap (which is milky) and the fruit have toxic properties.

HOMALINEÆ.

Homalium racemosum.—*Acouma.*

Incorruptible wood, good for water-wheels and buildings under water. It is very straight, and common in the forests of the island.

LAURINEÆ.

Nectandra sanguinea.—*Mountain Laurel.*

Light wood, for planks and staves. It is a very common tree in the northern forests of the island.

Nectandra concinna.—*Marble Laurel.*

This wood is in demand in cabinetmaking for beds, cabinets, bookcases, and flooring.

LEGUMINOUS.

Agati grandiflora.—*Vegetable Colibri.*

Soft and light wood, good for the making of common planks. The

Indians eat the seeds. The Javanese use the leaves as tea, and the gum is employed in China in dyeing. The seed gives a tree in the course of a year.

Adenanthera pavonina.—*Condoré*, or *Peacock's Eye.*

Large and beautiful tree; good for furniture and carpentry. The seeds, which are red, are used for necklaces.

Hymenœa courbaril.

This is an excellent cabinetmaking wood, very extensive in the vicinity of water-courses.

Hæmatoxylon campechianum.—*Logwood.*

Hard, heavy, and compact wood, adapted fór furniture-making, and almost exclusively employed in dyeing. The bark and gum are used by the medical faculty as astringents. The tallest trees are met in the communes of St. Esprit and the River Pilote.

Acacia bucocephala.—" *Wrapper* " *Macata.*

This is a pretty marquetry wood, common in the vicinity of St. Pierre, but seldom of a diameter sufficient to permit a profitable exploitation.

Ingadulcis.—*Sweet Wood.*

Beautiful tree, with white and hard wood, excellent for building; its bark is astringent; the negroes boil and eat the fruit. It is very common in forests which are at an altitude of from 900 to 1000 ft.

Copaïfera officinalis.—*Copahu.*—Rather rare.

MAGNOLIACEÆ.

Talauma plumieri.—*Pine Wood.*

Largely employed in building and marquetry; when it is old, this wood is as black as ebony.

MALPHIGIACEÆ.

Malphigia punicifolia.—*Cherry-tree* for marquetry.

Byrsonima spicata.—*Tan Wood.*

Good for joinery and buildings; in the colony the bark is used in tannage.

MALVACEÆ.

Thespesia populnea.—*Catalpa.*

Excellent carriage wood; the seeds are oleaginous.

POLYGONEÆ.

Cocoloba pubescens.—Large-leafed *Raisin-tree.*

The trunk of this tree, common in the Lamantin forests, possesses the

advantage of being very straight, even to a great height. It provides an excellent cabinetmaking wood.

RHIZOPHOREÆ.

Rhizophora gymnorhiza.—*Mangrove-tree.*

Good carpentry wood; its bark serves as a black dye. It is very common upon the littoral of the communes of Fort de France, Lamentin, and of the Briny River.

RUBICEÆ.

Chimarrhis cymosa.

Tall tree; its wood can be beautifully polished; it is useful for furniture-making. It is rather common in mountain ravines, and upon the banks of streams. Its timber is much sought after.

Exostema floribundum.—*Quinquina.*—Tobacco wood.

This tree is about 50 ft. high, with a diameter of about 1½ ft. It possesses febrifugal properties, but its bark contains an emetic and cathartic principle which makes its use difficult; it serves, however, in dyeing. Its wood, employed in the building of huts, is incorruptible. It is rather plentiful in the commune of St. Luce.

SIMARUBEÆ.

Quassia amara.

This is not employed as wood; the tree was introduced from Guiana; it is rather extensive in the neighbourhood of St. Pierre. The bark and wood are tonic, bitter, and febrifuge.

Bittera febrifuga.—Both wood and bark are tonic.

STERCULIACEÆ.

Ochroma lagopus.—*Floating Wood.*

This tree, rather plentiful in the communes of the north of Martinique, usefully replaces cork in a number of ways. Its fruit, known under the name of *patte-de-lièvre* (hare's foot), furnishes wadding and eider-down.

TILIACEÆ.

Sloanea Massoni.—*Cocoa Chestnut-tree.*

Suitable for the making of planks. It is found at an altitude of about 1250 ft.

VERBENACEÆ.

Vitex divaricata.—*Lizard Wood.*

Useful for planks and small furniture; this beautiful tree, which sometimes acquires an enormous diameter, is common in the colony.

ZANTHOXYLEÆ.

Zanthoxylon tragodes.—Fagara tragodes.—Nut-tree.

This timber is adapted for cabinetmaking, diffusing a very agreeable and persistent odour; it is largely employed for the making of glove-boxes.

Zanthoxylum cariboeum or **fraxineum.**—*Clavalier.*

This is a thorny tree of average size, in demand for building. Its bark dyes yellow, and was for a long time recommended as an excellent febrifuge. It is very common in Martinique.

GUADALOUPE.

Guadaloupe still contains a rather large quantity of timber in its mountainous regions, its forests covering a superficial area of about 87,500 acres.

The green ebony, the laurel-rose of the Antilles, the walnut-tree, logwood, and almost all the species of Martinique, grow in abundance there; but, owing to the scarcity of roads, there is only a moderate commerce in timber.

In addition to the cabinetmaking timbers, there exists in the colony a large variety of wood adapted for carpentry, carriage-work, and even timber of the very largest dimensions for shipbuilding.

UNITED STATES.

A detailed description of the forest wealth of the extensive American Republic would carry us a great deal too far. According to the latitudes, the majority of the varieties which have been already noted are found in these countries. We will, therefore, limit ourselves to saying a few words as to one of the States which is the richest from the forest point of view.

The State of Maine still possesses 40,000 square kilometres of forest. But for fifty years, as in many other countries, the forests of the country have been laid waste in a deplorable manner. The gigantic white pine, which was so valuable, has become very rare. However, some white pines, measuring in diameter about 6½ ft., and in height about 240 ft., can still be found in certain parts of Maine.

The yellow pine—a tree none the less beautiful, and which grows

in Maine—almost acquires the dimensions of the foregoing; its wood is harder, and the grain is closer; it is usually employed for the decks of ships.

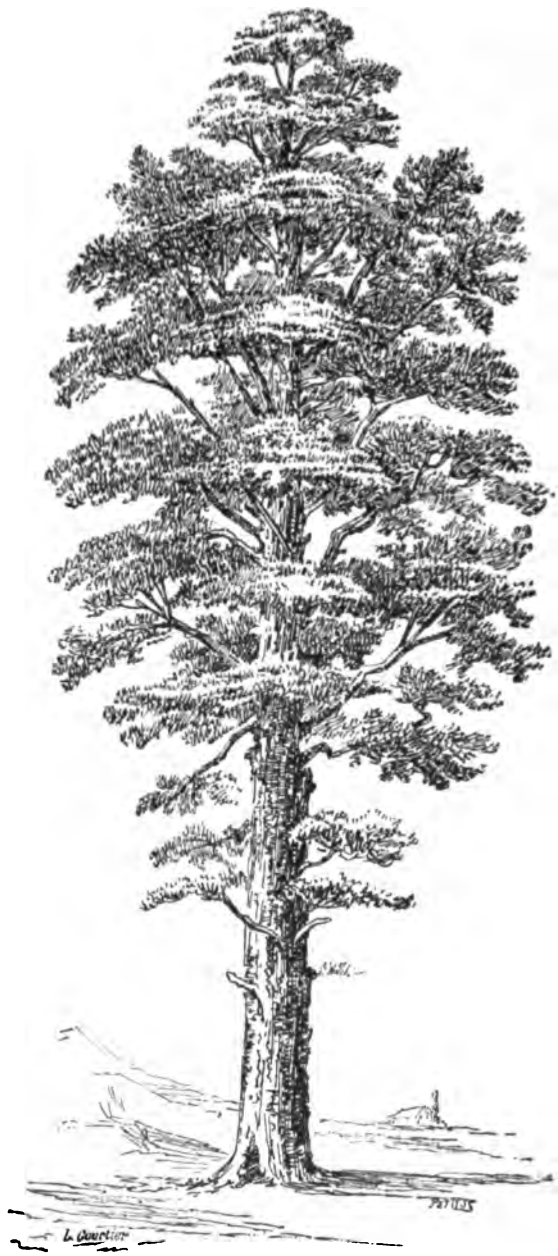

FIG. 111.—Californian Wellingtonia.

Norwegian pine is smaller, but the branches are more extended. The wood is close-grained and the bark coarse.

The resinous pine (*pitch pine*) is found in some parts of Maine. It is employed as a combustible to develop a high temperature.

Outside of the different species of pine, the most important varieties found in the forests of this State are the elm, platane, maple, beech, then, in decreasing proportion, the oak, birch, lime, and ash. Among the smaller trees, the larch, cedar, fir, poplar, and wild cherry-trees are especially found.

The principal forms under which the timber is put into commerce are as beams, planks, and logs.

Coarser pine wood has taken the place of that of the first-class or white pine, which has principally disappeared; the best timber actually obtained upon the banks of the Penobscot, Kennebec, and other large rivers is that from the fir-tree.

The principal timber market of Maine is always at Bangor, upon the banks of the Penobscot.

Planks about 100 ft. long and 6½ ft. broad without a single knot are the current merchandise. These planks are obtained from gigantic fir-trees.

The forests producing these firs are so vast that, although the saw-mills of the neighbourhood have sold 500 million ft. of lumber per year for the last ten years, the voids made by this vast consumption hardly seem to have left any trace beyond the formation of forest paths.

In general it may be said that the United States are especially favoured, from the point of view of the production of building timber. Their stock of this article is practically inexhaustible, whilst in quality and variety these timbers are equal to those of any other country in the world.

The immense enclosures of forests of the north-west alone are of sufficient extent to supply, for some time to come, the needs of a market whose importance is increasing without cessation.

According to the last census, there were in the United States 25,700 establishments devoted to wood-sawing, with a total capital of 182,000 dollars. The manufacture of sashes of windows and doors occupied 1300 factories.

When one considers the quantities of wood employed and the capital placed in the construction of ships and docks, in that of dwellings, waggons, carriages, tramways, carpentry machines, and in the innumerable industries into which wood enters largely, an idea will be obtained of the value and importance of the timber trade to the United States.

In the year 1888 the exportation of timber rose to the figure of 24 million dollars.

CANADA.

Instead of species peculiar to the country, Canada has specimens of all the species distributed over Europe; the walnut, elm, red pine, ash, and the oaks especially dominate there. A country is thus recognised whose climate possesses the greatest analogies with that of Europe.

However, American forests have a special aspect; the leaves of the trees are, as a rule, not so deeply denticulated nor so broad and petioled as those of their European congeners. As they fade, these leaves usually take more brilliant colours than the autumnal tints of our trees. The seeds have a smaller volume, the buds are not so numerous, and consequently spaced out more. But where the difference is especially noticeable is the general aspect of the plants. The giants of the American forests have still fewer small branches and far more vigorous boughs, which naturally give them a much more irregular and wilder aspect than that of the trees of our woods.

We cannot go into the enumeration of all the timber belonging to the Canadian flora, the following only being cited amongst the most important: the maple, the clouded ash, the veneer of which can be compared to a cloth of gold, several varieties of oak, the clouded walnut, etc.

Timber comes into the Canadian markets in the following forms:— Laths, staves, logs, spars, curved wood, shingles, and squared wood.

The following are the specific gravities of the principal timber of the country:—

Tulip	0·65	White oak	0·80
White wood	0·45	Beech	0·65
Hard maple	0·75	Red cherry	0·70
Tender ,,	0·60	Poplar	0·50
Black cherry	0·60	Red pine	0·65
White ash	0·60	Yellow pine	0·50
Black ,,	0·65	Fir	0·40
White elm	0·65	Red fir	0·60
Tender walnut	0·55	White fir	0·45
Black ,,	0·60	Black ,,	0·50
Hard ,,	0·90	White cedar	0·35

CHAPTER XI.

TIMBER OF OCEANIA.

AUSTRALIA.

THE fauna of Australia is so different from that of other parts of the world that it appears impossible to consider this part of the globe as contemporary of the others. One would believe himself transported to the secondary or tertiary period. The plants present anomalies so that they resemble more those of the tertiary epoch than those of modern times. They present forms more ancient than those of contemporary plants.

More than nine-tenths of the varieties met with between the 33rd and 35th degrees south of Australia are absolutely peculiar to these regions.

Several constitute quite distinct families; others form families which are scarcely represented upon other points of the globe.

The *Eucalyptus* among the *Myrbaceæ*, the *Acacia* among the *Leguminous* family, form, by their number and dimensions, about half of the vegetation covering these lands.

The *Eucalyptus*, which occupies so large a place in Australian vegetation, serves to shade, in the middle of woods, the tombs of savages.

If to the beautiful *Eucalyptus* and *Mimosas* predominating in the Australian forests are added the *Xanthorrhea*, with thick stem and narrow leaves; the *Casuarina*, with long, pendant, weeping branches; the *Araucaria excelsa*, which raises its trunk in the form of a column even to a height of about 100 ft.; and the elegant *Epacrideæ*, an idea will be obtained of the vegetable wealth of the Australian coasts.

VICTORIA.

In this portion of the Australian continent, constituting the colony to which the name "Victoria" has been given, the vegetation of the

Eucalyptus species makes room, up to a certain point, for the trees of the Indian type, with horizontal leaves and dense foliage.

In this country the extent of the forest region forms a superficial area almost without solution of continuity upon the mountain slopes of the south and east.

It is there where the Eucalyptus flourishes in all its grandeur, attaining enormous proportions.

Amongst the most highly esteemed native trees is the *Red Gum* (*Gommier rouge*), a timber with very strong density, very hard, and of a very remarkable circular vein, and which does not offer the same disadvantage as the Eucalyptus, namely, cracking.

The **Red Gum** changes neither in damp soils nor in sweet or salt water. It is the most useful timber for the erection of machines or the building of houses. It resists considerable pressure. This wood has no equal for the construction of bridges and for railway sleepers. The piles made from the red gum, though rough and rugged, last twice as long as those made from any other wood. It is equally employed for the fellies of wheels.

As firewood it has a great value; it is considered superior to all others for its beautiful flame and the degree of heat which it develops.

The **Blue Gum**, which is only found in the southern and eastern portions of the colony, grows in large proportions upon every kind of soil. It is very useful, not only as timber, but also for the oil which it produces, the exportation of which is enormous.

The oil extracted from the *Eucalyptus globulus*, on account of its medicinal properties and tonic, stimulating, and antiseptic qualities, is largely employed in Europe.

The liquid extracted from the leaves of this tree in the amorphous state is a febrifuge, easily arresting malaria.

The wood of the blue gum is of a greyish-yellow colour, of straight vein, very dense and hard. It is specially useful on account of its flexibility; it makes very good girders and saws easily.

The **Stringy Bark** (*arbre à écorce fibreuse*) has the appearance of boxwood, with a deeper tint. It is employed for palisades, laths, lattice-work, and barriers; but it has a tendency to swell and rot.

The **Messinate** is employed for stakes of second quality, barriers, laths, palisades, as well as for wheelmaking.

The **White Gum** is that of the trees of the colony which is the least valuable; it is scarcely suitable for fuel.

Blood Wood (*bois de sang*) is more especially found in the eastern portion of Gippsland.

The **Black Wood** and the **Light Wood** grow upon rich soils, and in the damp earth of the high lands, where they attain large proportions. The wood of these trees is very valuable; it is often employed in joinery, being of a pretty colour, magnificent grain, and polishes as well as walnut. Its strength and flexibility are qualities which are highly appreciated.

The **Murray Pine**, magnificently marked, is constantly employed in the north of the colony, being highly appreciated at Melbourne.

The **Myall**, a small variety of the preceding, diffuses an agreeable odour. It is principally used for making whip-handles, smoking pipes, and other turned articles.

Iron Bark (*écorce de fer*), the hardest and heaviest of Australian timbers, does not grow in large quantities in Victoria; it is very tenacious and strong. Wheelwrights utilise it for making hand-barrows and fellies.

The **Wattle** (*bois tressé*), from which staves are made, is largely employed by tanners and dyers.

The **Fern-tree** and **Pencil Wood** (*bois à crayon*) have very limited usages.

The soil of this part of Australia, where the Eucalyptus, with its oil, resin, and useful principles, produces potash, tar, varnish, alcohol wood, and bitter wood, would also be able to grow the platane, cork-tree, sycamore, and even the species of our Alpine regions.

NEW SOUTH WALES.

In New South Wales, which so admirably completes the network of the British colonies of Australia, all the varieties of timber found in the northern and southern districts of Australia are met with.

The most useful of the four hundred species or varieties of trees composing the flora of this country are the following:—

Ash, *Flindersia Australis.*
Beech, *Vitex Leichhardtii.*
Cedar, *Cedrela Australis.*
Iron Bark, *Eucalyptus.*
Moreton Bay Pine, *Araucaria Cunninghamii.*
Rosewood, *Synoum glandulosa.*
Silky Oak, *Grevillea robusta.*
Tulipwood, *Owenia venosa.*

NEW ZEALAND.

In the large island Ika-na-Mawi enormous forests are found filled with convolvulus and shrubs interlaced, which render them impenetrable. These forests include gigantic trees, from which canoes are made from a single piece of timber of about 65 ft. long.

Along the coasts enormous marshy spaces are found, covered by a large group of green trees, of which the *Dacrydium cupressinum* and the *Podocarpus dacrydioïdes* form the principal varieties.

Amongst the palm-trees may be cited the arborescent *Dracænas*, a conifer with large leaves, the *Dammara*, and amongst the Myrtaceæ some *Metrosideros.*

NEW CALEDONIA.

The forest resources of this colony are still rather extensive. The beautiful forests formerly covering this large island have for a long time been devastated by English and American commerce; they require, in order to reassume their ancient splendour, to be submitted to forest regulations, energetically and intelligently directed.

The commonest trees in this country are the **Niaouli** or *Melaleuca viridiflora*, the **Banana-tree,** the **Bancoulier, Cocoa-tree, Orange-tree, Ricinus, Casuarina** (or *Ironwood*), and **Acacias.**

BANCOULIER.

The *bancoulier* (*Aleurites triloba*) is the most extensive variety in this country, and the only one living in families in the mountain forests.

This euphorbia, which attains in the Moluccas, its country of origin, only a medium height, assumes in New Caledonia a considerable development; as a matter of fact, this tree may attain a height of about 60 ft., by a circumference at the base of 5 ft. The fruit is a fleshy drupe, generally formed by a single cell by lack of development. The seed is inclosed in a hard shell, which is charged with calcareous efflorescence upon getting old, when it has fallen upon the earth. It burns very regularly, and gives off great heat and a very thick black smoke.

The nut of the bancoul usually weighs 10 grms.; and a tree may bear about 2000 nuts. The oil extracted therefrom is limpid and brownish, being useful for painting and lighting purposes. It burns with a very clear bright flame; employed in painting, it dries very quickly, especially when it has been boiled.

To prepare this oil, the most primitive process consists in exposing the nuts to the sun for some hours. The almond, losing its water, then becomes easily detached from the shell in a single mass and at the first stroke of the hammer. These almonds (ground) are disposed in small heaps upon an inclined metallic plate; the whole is exposed to the sun; the oil comes away slowly, losing the water which it still contains, and flows through channellings of the plate into a vase, where it is received. It is afterwards filtered. The amount produced by this almost barbarous process is insignificant, hardly exceeding 6 per cent. By cold pressure the amount may be raised to 29 per cent.; by hot pressure it may reach 34 per cent.

If the oil-cakes are treated afresh, the result may be 66 per cent.; 300 kilos. of nuts are therefore necessary to give 100 kilos. of almonds or 66 kilos. of oil.

The growth of the bancoulier is rapid, and at the end of four years it commences to produce.

Oil is not the only product extracted from this fruit; a light-coloured gum flows from the bark of the tree which is of some value. Moreover, the nut-shells, treated with alcohol, give a deep red dye-stuff.

The bark of the tree furnishes a brownish red or blackish dye; it also has a good amount of tannin. An adult tree which has been felled may supply about 35 kilos. of bark, though it does not easily lend itself to barking.

The timber is useful for packing and also for joinery-work, but after prolonged immersion in briny water it acquires good qualities, its durability is increased, and it may be of use in building.

Banana-Tree.

This is a type of the Musaceæ family. The native banana-tree (*Musa fehi*), or red banana-tree, grows in a wild state in the damp valleys of the central chain of the isle, near streams. The trunk of it is soft and as straight as a column, of a beautiful deep violet colour, with broad deep green marblings. The leaves are of a pretty green, slightly spotted with violet; the fruit is edible when cooked.

An incision into the trunk of this beautiful plant brings forth in abundance a deep violet liquid like ink, which contains a certain quantity of tannin, chlorophyll, a gum, and the ordinary principles of vegetable juices in general. Left to itself, this juice ferments without becoming decolorised; even after prolonged boiling and having been carefully bottled, it ferments and bursts the bottle.

In the presence of acids, this juice takes a very bright carmine tint, which changes rapidly upon exposure to the air. The bases communicate to it a magnificent green colour, which eventually turns to greenish brown. With the addition of alcohol, this juice ceases to ferment. If a little gum is carefully added to it, it may serve as an ink; the stains which it leaves upon linen resists washing with soda, and hence it can be employed as marking-ink.

If, after long boiling of the liquid in the presence of a base, some drops of acid are poured into it, a beautiful brownish-yellow dye-stuff is obtained, which dyes well without a mordant. The colouring matter of the *musa fehi* can be precipitated, either by prolonged boiling or by pure alcohol.

Writing traced with the juice of this tree quickly turns yellow, reddens on the application of acids, but without disappearing; it soaks into the paper in such a manner that the decolouring products do not act upon it, unless by attacking the paper itself. This ink might therefore have some very interesting applications.

The sap of the *musa fehi* is without action upon litmus paper.

Sulphuric, nitric, hydrochloric, oxalic, and tartaric acids poured into this sap give a carmine red liquid which dyes materials a bright rose colour when they are dry.

Arsenious acid gives a violet liquid.

Caustic potash produces a deep green liquid which, upon exposure to the air, becomes yellowish, and which dyes tissues a yellow ochreous colour.

Soda gives a deep green liquid, with an abundant gummy precipitate.

Tartar-emetic gives an azure-blue lake.

The produce per tree is from 6 to 8 litres when it is bled. But if, at the time of fruit-gathering, the tree is cut down and the trunk is passed to the press, 20 litres of liquid can be obtained.

The banana can be preserved, cut in rings or sun-dried, like the fig or date.

Quite ripe and placed to ferment in water, it gives a vinous beverage, sparkling, agreeable, and refreshing. This liquor, distilled, produces banana brandy, the taste of which is rather agreeable. The yield is rather considerable, for with the ripe raw banana it amounts to 17 per cent., and with the cooked banana it may reach 21 per cent. This yield is proportional to the volume of peeled fruit; the waste is rather large, the fruit-skin forming as a rule a sixth of the total volume.

The magnificent silvery fibres of the banana-tree of New Caledonia was particularly noticed at the Universal Exposition of 1889. These fibres can be utilised in paper-making, as likewise in weaving, for they are silvery and supple.

Cocoa-Nut Palm.

Of the *Palm-tree* family, Cocoïneæ tribe, this variety contains trees of gigantic size, natives of India. It is found extensively in New Caledonia.

The most remarkable variety is the common cocoa-tree, whose trunk may rise to an altitude of about 80 ft. It is crowned by a magnificent cluster of leaves of a beautiful green colour, in the centre of which is found a terminal bud.

The fruits have, under a stringy husk, a nut of a ligneous tissue, which is extremely hard, and of slightly pointed oblong form. This nut, which is called cocoa-nut, encases a very white pulp, similar to a thick cream of very agreeable taste, and containing a refreshing liquor of milky colour and slightly sweetened. Upon ripening, the pulp of the cocoa is first changed into a white and succulent kernel, finishing, when the fruit is old, by becoming coriaceous and stringy.

The yield of the fruit of the cocoa-tree, deprived of its shell, is about 22 per cent. in oil. This fresh oil is excellent for the *cuisine*, but with age it acquires an insipid and disagreeable odour. It burns with a rather smoky flame, and may also be utilised in soapmaking. When it is left in the cool air, and especially in earthenware bowls, it forms a light, white, fatty mass, called "cocoa butter," which keeps well when wrapped in waxed-paper.

It is this floating matter which thickens cocoa-oil, giving it a milky appearance.

The natives strip the cocoa-nuts with wonderful rapidity. To remove the husk they drive a stick, pointed at both ends with hard wood, into the ground, inclined about 60°. They support their big toes against this wood, raise the nut with both hands, and throw it with force against this stick, which penetrates the fibrous husk. A simple reversing movement detaches a portion of this husk. In three or four blows the nut is stripped, so that a man can prepare more than a hundred nuts an hour. The nut is afterwards broken, and the concave part is placed on a small board not quite so large as the average diameter of the nuts, rounded at the extremity in a semicircle and provided with sawing teeth. By rapidly turning the nut upon this very primitive instrument, the natives clear out the interior of the shell, whilst the pieces fall at their feet into a receptacle. By exposing the nuts

for some minutes in an oven, the kernel is easily detached from the shell by a blow of the hammer.

Coprah is nothing else but the ripened kernel of the cocoa, coarsely cut into fragments and dried in the sun upon the ground. This product, though of mediocre quality, has an assured sale.

Each cocoa-tree gives on an average eighty nuts per year. As a rule, 700 trunks per hectare (2½ acres) can be planted, each nut producing 600 grms. of coprah.

If care be exercised in filtering the oils upon their coming from the presses after having precipitated the mucilaginous matters by sulphuric acid or by some other process, they become limpid, and are valued from a commercial point of view.

The husk weighs on the average 800 grms. Beaten and combed after steeping, it furnishes cords, which are highly esteemed, light, and reputedly imputrescible. The meshes of these fibres are charged with a light substance as elastic as cork. Brushmakers find these fibres valuable for the making of brushes for rough work such as whitewashing.

The fibres of the trunk of cocoa-trees may also be useful for making palliasses and light basket ware. By plaiting them, excellent cables can even be made.

Lastly, very good spirits is made from the cocoa-milk. Indeed, the fruit of the cocoa-tree contains a liquid susceptible of fermenting and being transformed into alcohol. Cocoa-milk ferments rather quickly, and after two distillations gives about 5 per cent. of rather fine spirits, which improves with age. When cocoa-oil is prepared, this liquid, which flows the moment the nut is broken, can be gathered. The average quantity of milk contained in the ripe nuts is about ⅕th litre.

NIAOULI.

The *Niaouli* (*Melaleuca viridiflora*) is the most extensive variety in New Caledonia, and that which has the best future.

The leaves of this tree give a tincture and an essence which have taken a place in the French Pharmacopœia. By distillation they also give off a brown and limpid oil and a chamois dye, which can be applied without a mordant.

The wood, which is hard and supple, turns well, admirably suiting carriage-work.

This is the only tree which in this colony permits herbage to develop under its shade. This is due to the fact that the leaves turn

their edge obliquely to the sun, and not horizontally, as a consequence of which their surface is perpendicular to the soil. The seeds, which are very light, are unfortunately dispersed by the wind, and multiply the young plants in such a manner as to choke the grass and diminish the value of the pasturage.

The foliated buds present upon opening a cluster of fine silvery and silky leaves which give a stimulating stomachic tea, which is very aromatic. This tea diffuses a very agreeable perfume, approaching that of the rose. The preparation of this is most simple, all that is necessary being to gather, with care, the terminal buds, half-faded, and to allow them to dry in the shade.

By successive distillations, the leaves of the niaouli produce a limpid and very mobile essence, of a penetrating odour, and at the same time a heavy, brown oil, very analogous to cajeput oil. The odour of turpentine, camphor, and essence of rose, with a trace of mint, are recognised in this oil. The perfume is sharp and penetrating. This oil is soluble in alcohol and sulphuric ether. It appears to enjoy the stimulating properties of cajeput oil, which is extracted from the *Melaleuca cajeputi* of the Moluccas. It can be employed as an embrocation for acute rheumatism.

This oil, denser than the essence, sinks to the bottom of the vessel; it is separated by decantation, and then filtered. The yield is small.

The tincture, distilled afresh and then rectified, gives the essence of niaouli, which burns with a very white and sooty flame. The savour of it is sharp and burning; it produces, like turpentine, under the influence of a current of hydrochloric acid, a solid, crystalline, white product, which resembles artificial camphor.

This variety appears to be a very powerful antiseptic.

The yield of niaouli leaves in essence is very variable, according to the seasons and the age of the leaves or trees.

Orange-Tree.

Orange-trees grow in New Caledonia with the greatest facility. They were imported from Tahiti in 1857, and since then have become rapidly acclimatised and multiplied.

The products which can be extracted from them are very various: wine, alcohol, an essential oil from the leaves and from the peel of the fruit, curaçao, etc.

The essential oil of the leaves is extracted by distillation. When the branches are cleared to permit of the air circulating and to arrest

development of the kermes (*Lecanium hesperidium*), which increase in slightly shady and damp localities, the leaves obtained may be used in the following way:—They are placed either in a sack with large meshes or upon a grill, so that the steam, in destroying the parenchyma, only carries away with it the essential oil with which the foliated glands are charged. The odour of it is delicate, and the yield, though rather small, varies from 1 to 3 per cent. One drop in a glass of water is sufficient to flavour it.

The essence from the orange-peel is of relatively considerable yield, being on the average equal to 1 per cent.

Extraction can be made by two processes: compression and distillation. A very simple and easily worked machine can be employed for this purpose, consisting in an endless band of linen, faced with fine cards, like the cards used in a spinning mill, and turning by the aid of two cylinders between planks. The linen is opened; the oranges are placed in it side by side upon one side of it and the cylinders are made to revolve. The card facing the linen, turning in opposite directions, roughly brushes and cuts the orange-peel. The same movement makes the oranges roll about, and in a few minutes a hundred oranges are deprived of the essential oil of the peel. The holes in the linen facilitate the running away of the liquid mixed with some *débris* of the peel. The whole is pressed, and the essence is filtered several times. This process gives a satisfactory yield, though distillation provides a clearer product.

Fresh peels yield less when they are whole than after having been cut in pieces, and they give a product inferior (in perfume) to that obtained from dry peel. Among these last, those which have been stored, sheltered from air and dust, are the best, the produce of them being finer.

Orange-wine is a very interesting liqueur, the manufacture of which is simple. It consists in peeling the oranges, throwing them in a mortar, where they are mashed up by the aid of a piece of wood. It is necessary to avoid iron, which promotes the formation of black citrates of disagreeable appearance. The pulp, thus triturated, is placed in a cloth stocking, which is pressed so as to make the juice alone come out, without bursting the pips, which make the liquid bitter. Placed to ferment in a cask standing upright, this liquid soon becomes clear, especially if the surface be carefully skimmed. It is then carefully decanted, and poured into a barrel into which some grammes of tartrate of potash have been previously thrown. This barrel must be kept constantly full. It is then that a slower and second fermentation is commenced. In a few

weeks' time the wine will be made. The value of this wine increases with age. Orange-juice boiled, then fermented, gives an even finer wine.

Submitted to distillation, this liqueur becomes transformed into spirits of a very agreeable taste. The yield is from 5 per cent. for spirits at 52°.

As has been seen, the orange is a precious tree for this colony. It only suffers from the presence of innumerable coccidiens, the kermes of the orange-tree. This is easily got rid of by painting the tree with milk of lime, diluted in ash-lye, and especially by proper pruning. A well-cared-for tree may bear as many as 2000 oranges.

Ricinus (*Castor-oil Plant*).

The *Ricinus* was probably imported from India into New Caledonia, the same as it has been into Tahiti. Since that time it has been reproduced in the wild state with the greatest facility.

The common ricinus (*Ricinus communis*) is a shrub about 13 ft. high, with a trunk which is greyish and ligneous, formed of a light wood, which certain tribes employ cut in pieces. The capsules, of an ash-green, have soft points. The seeds are of a beautiful grey colour, spotted and striated with reddish brown. The kernel, which is highly charged with oil, is white and firm.

The *Ricinus viridis* has smaller leaves, of a deeper green colour. The smaller pods are furnished with harder points, and the seeds are much smaller. This variety is the most extensive.

The *Ricinus rubricaulis* has a red trunk, covered by a whitish waxy dust; its seeds are larger, and contain a good amount of oil.

The ricinus seeds submitted to the press give 36 per cent. of oil when cold; when warm, the yield rises to 56 per cent. Pressure must be effected slowly and with precaution, by reason even of the viscosity of the liquid, which can only be freed with difficulty.

The ricinus succeeds in all kinds of soil, though it appears to prefer those which are mellow or alluvial.

PART IV.

FORESTS.

CHAPTER XII.

GENERAL NOTES AS TO FORESTS: THEIR INFLUENCE.

To speak only of France, we have already said that there still exist in that country about 22 million acres covered by woods and forests. The production of wood therefore constitutes a very important branch of agriculture.

If the forest in savage and badly organised communities is left in the charge of Nature, it is no longer so in thickly inhabited countries which have arrived at a certain state of civilisation.

The need of cultivating the land compels man, first of all, to clear spaces covered by forests. By degrees the woods are found confined to land of difficult culture, upon steep slopes, chilly summits, and in the poorest soils.

Those men who devote their existence to the improvement of methods of turning the wealth of the forest to account, who find means of augmenting the products of our woods, and who, by their researches, raise the cultivation of timber to the rank of an industry —those men most assuredly deserve public recognition.

Amongst those who have successfully busied themselves with this question of forests may be mentioned in the first rank, M. Chevandier de Valdrôme.

His first labours have had as their object the substitution of the always uncertain measures of timber in volume by their estimation in weight in the state of absolute dryness. He then determined the quantities of carbon, hydrogen, oxygen, and nitrogen contained in a stère of different native woods, and he established what was the calorific

power of these particular timbers. He showed what a hectare (about $2\frac{1}{2}$ acres) of forest, under ordinary conditions, produces in France, each year, in green and dry timber, elementary principles and calorific power.

His long and costly experiments have thus enabled him to discuss the different methods of exploitation in use.

He has also placed two new orders of facts in evidence. He has proved that manures may be profitably used in the cultivation of young forests, and that the irrigation or retention of water on sloping land favours to a high degree the growth of trees of all ages.

To show the means of obtaining from existing forests the largest amount of useful products, in assuring the maintenance of their yield, to make known the methods by which it is possible to convert into productive forest those soils which have not until now lent themselves to any cultivation—such is the object of *sylviculture*, of which we are about to treat.

Considered from different points of view, this science treats—

(1) Of the creation of new forests and the maintenance and improvement of existing ones.

(2) Of the planting of every kind of soil, however limited it may be, when it is found that it cannot give any other remunerative product.

(3) Of the formation of enclosures, hedges, shelters, etc.—in a word, of every plantation where forest trees, properly so called, can be utilised.

ACTION OF PLANTS UPON THE ATMOSPHERE.

Influence exercised by Forests upon the Climate.

In order to give an account of the influence of forests upon the climate of a country and of the hygienic conditions brought about by the existence or absence of woods, we will say a few words as to the action of plants upon the atmosphere.

Plants, and especially all species of trees and shrubs, draw from the atmospheric air the materials necessary to their existence; they all spring from a seed coming from a plant of the same nature. The seed, in a suitable state of desiccation, appears to be preserved indefinitely, without alteration, if it is preserved from damp and the attacks of insects. But if it comes into contact with water under the influence of a temperature which must not be too low, it is not long in swelling. The ligneous envelope cracks, and there springs forth

from one side the filaments called the radicles, which seek to penetrate into the soil, and from the other, a small stem, the shoot, which takes an opposite direction and tends to rise into the air.

These first developments of the vegetative life are brought about at the expense of the amylaceous matter of the seed; an azotised principle, the diastase, is formed there, the principal property of which is to rapidly change the starch into dextrine and sugar—that is to say, into soluble principles, which are organised afresh and transformed into cellulose, which serves in the formation of the first cellular tissues of the plant and root.

During this first period of vegetable life carbonic acid is given off. The presence of oxygen appears essential, for the moist seeds do not germinate in an atmosphere deprived of this gas. The parts of the seed which have furnished the amylaceous matter, the cotyledons, have lost their consistency and shrivel up.

Brought in contact with air, the sprout assumes a green colour and the first leaves are developed.

The assimilation phenomena then completely change, and it is principally from the atmosphere that the new plant receives those elements which are necessary to its growth. Its green portions, the leaves especially, absorb, under the influence of the solar light, the carbonic acid of the air, assimilate the carbon, and throw back the oxygen into the atmosphere. They possess besides a certain quantity of nitrogen, which is useful in the formation of the nitrogenised principles which are essential to the life of the plant. As to the hydrogen, it is evidently provided by the water coming both from the vapour in the atmosphere and the dampness of the soil. The largest portion of this water remains in the plant, forming the sap, which serves to transport to the different parts of the plant the nutritive principles rendered soluble. Another part of the water is decomposed under the influence of vegetative forces into hydrogen, which is assimilated, and into oxygen, which is disengaged with that arising from the more or less complete decomposition of the carbonic acid.

As will be understood after what has just been said, the soil does not play an inert *rôle* in the development of the plant—very far from it.

When the soil is deprived of decomposing organic matters, it loses all its fertility, only giving birth to poor plants. To give it this fertility, it is necessary to bury new organic detritus in it, principally animal substances constituting natural manures or alkaline and nitrogenised chemical compounds forming artificial manures.

The manures provide the roots with organic matters, principally nitrogenised substances which the plant assimilates; they contain, moreover, mineral principles which are soluble or rendered soluble by the chemical action which is developed in the soil.

These principles, which are found in the ashes of the plant, are necessary for its good constitution. When they are missing in the soil or are there in insufficient quantity, the plants remain straggling, develop but little, and cannot form the mineral frame essential to the majority of them.

The decomposition of the carbonic acid by the green portions of the plants can easily be demonstrated.

If some fresh leaves are placed in a vessel partially filled with water and carbonic acid gas, and the vessel then exposed to the sun, the carbonic acid disappears at the end of a certain time and is found replaced by a lesser volume of oxygen. As carbonic acid contains an equal volume of oxygen, it will be concluded from this experiment that all the oxygen of the carbonic acid has not been set free.

It is probable that the carbonic acid is only partially decomposed by the plant, that it is, for example, converted into oxide of carbon, which enters into the constitution of new organic substances, and that the remainder of the oxygen comes from the decomposition of the water.

If the branch of a tree is placed in a glass vessel exposed to the sun, and in which a mixture in known proportions of atmospheric air and carbonic acid is made to pass slowly, it is easy to recognise that the gas emanating from the vessel is almost entirely deprived of its carbonic acid, and that this latter is replaced by oxygen.

This decomposition of the carbonic acid by the leaves only takes place under the influence of the solar rays and of diffused daylight. In darkness or under the influence of artificial light, they act in an inverse manner. In this case, indeed, the leaves give off carbonic acid and absorb oxygen. If the effects of the day are compared with those of the night, it is known that the first carry it away, and that consequently the resultant action is that which takes place under the influence of solar rays.

The atmospheric air contains about five ten-thousandths of carbonic acid; this very feeble proportion is sufficient to furnish the carbon which accumulates in the plant. But this carbonic acid is without cessation restored to the terrestrial atmosphere by the respiration of animals, by the decomposition of the plants, and by certain chemical reactions which occur in the interior of the globe.

It is therefore seen what great influence the presence of a forest exercises over the composition of respirable air. The origin of forests goes back beyond the last cataclysms which have upset our planet. Their first function was to render it habitable; they deprived the atmosphere of the enormous quantity of carbonic acid which it contained, and transformed it into respirable air.

The presence of forests in a country is always a benefit, no matter from what point of view the matter is viewed, and in mountainous countries the following propositions are admitted as demonstrated by experience:—

(1) The presence of a forest upon a soil prevents the formation of floods.

(2) The laying waste of a forest gives rise to devastating floods.

(3) The development of forests promotes the extinction of floods.

(4) The decadence of forests increases the violence of torrents, and may even be the cause of their reproduction.

In the high regions of the Alps—that classic land of floods—numerous plantations of resinous varieties may be seen to-day, suited to the local climate, displaying their vigorous vegetation not only in the receiving basins of the floods they have prevented, but even upon the banks of the water-courses, keeping them within bounds, so that these torrents, formerly so dreaded, have become not only inoffensive streams, but all the more precious as they supply agriculture with better and more abundant irrigation waters.

One must, however, always guard against extremes; indeed, there can even be an excess of forests, though this is seldom the case.

Gaul, and especially Germany, two thousand years ago, were cold and wet countries, covered by marshes and forests. Successive clearings, however, converted them into fertile plains, and some portions of Germany only have still remained very thickly wooded.

On the other hand, excessive clearing, as will be seen further on, may exercise the most baneful influence on a country.

The clearings in the plains at first diminishes the quantity of springs in a district, which even become lost altogether. The land becomes dried up and exhausted. The Canary Isles, Madeira, and many other countries were, at the time of their discovery, veritable terrestrial paradises, and became later, when the forests were demolished, dry and uncultivated plains. The steppes of Russia have the same origin. Madeira, however, has lost nothing by the change, for chestnut-trees, lemon-trees, and the vine have replaced the forests which formerly covered it.

Bocage, in Vendee, suffered from an excess of humidity; since 1808 numerous clearings have been made, and since then the springs have disappeared or yield less water.

Prior to 1820, Provence possessed numerous springs and a number of rivers. In 1822 the olive-trees, which, so to speak, formed there complete plantings of trees, froze; they had consequently to be cut down, since which time the *régime* of the waters has changed to such an extent that the work of agriculture is often very difficult there.

In the heroic ages Greece, Sicily, and the surrounding islands were covered with dense woods. It was also the same in Italy. But the progress of events in these classic lands led to the almost complete destruction of these superb forests. These countries then became renowned for their agriculture, and to-day only a few trees are seen there at great distances between each other. The once celebrated springs no longer exist, the sterility of these countries having become proverbial.

It will be seen to what an extent the action exercised by forests over the climates is variable and complex.

The influence of forests over climate depends upon their extent, the height of the trees, and their nature; their evaporating power through the leaves, the faculty they possess of heating or cooling the air; and the nature and physical condition of the soil and subsoil.

As shelter against low winds, the usefulness of forests is evident, this being proportional to the height of the trees.

Evaporation by the leaves is a powerful and incessant cause of humidity; the slightest cooling of the air precipitates the vapour, the water resulting from it penetrating into the soil, or else it is absorbed by the roots. As for the calorific state of the trees, it is shown that they become heated and cold again in the air—the same as all non-organised bodies—by the action of the sun. Being bad conductors, they take the same temperature as the air only at the end of a rather long time. The tree, heated during the whole day by the sun's rays, escapes to a large extent the cold of night, restoring by degrees to the surrounding air the heat which it has absorbed. These facts have been proved and established by M. Becquerel by the aid of the electrical thermometer.

Boussingault, studying the equinoctial regions of America, found that abundance of forests and dampness tend to make the climate cold, whilst dryness and aridity of the soil make it warm.

De Humboldt, on the contrary, has proved that in Northern America the climate has not changed by the destruction of forests; but in the

comparison of these too opposite opinions, it is necessary to take account of the nature of the soil, which is far from being the same in the two countries studied by these *savants*.

In conclusion, it may be said with M. Becquerel, that there is no doubt that the climate of a country is improved by the grubbing up of heaths, making marshy land wholesome, and planting mountains and agricultural soil, and that excessive clearing is neither useful nor necessary.

CHAPTER XIII.

OPINIONS AS TO SYLVICULTURE—IMPROVEMENT OF FORESTS.

DIFFERENT VARIETIES OF WOODS AND FORESTS.

As a general rule, forests are a natural production, planted forests only existing in certain countries where sylviculture is already in a very advanced stage. But the majority of planted forests whose cultivation is abandoned soon resemble natural forests. Some inferior varieties are introduced, and the forest becomes uncultivated if it is left to Nature; if, on the other hand, it is carefully attended to, it passes into the category of cultivated forests.

Coppices are woods which are usually cut rather young to make firewood or to be converted into charcoal, or sometimes to be used as vine-props, hoops, and stakes.

Coppices have as a distinctive sign that they shoot from their stocks, whilst the *forests* are restocked by *seeds.* Resinous trees not springing from their stocks do not form coppices.

Coppice woods are divided into three classes. *Young Coppices* are exploited when from 8 to 9 years old. They are nut-trees, chestnut-trees, and birch-trees, employed especially for heating purposes by the peasantry.

Medium Coppices are exploited at the age of about 20 years; charcoal and small firewood are obtained from them.

Timber Coppices are exploited between 20 and 140 years. They furnish firewood, small pieces of timber for carpentry, and especially split wood for vine-props.

Forests are divided into several classes. *Young Forest* is composed of trees whose age is comprised between 40 and 50 years.

"*Half-Forest*" (*demi-futaie*) is from 50 to 60 years old.

And last, *Timber Forest* is that whose age reaches 100 years.

In France the forests form groups which are exploited on the *gardening* method (*jardinage*). The ripe trees are chosen and cut down.

Sometimes also trees whose age exceeds 100 years are called "old barks."

VARIETIES ADAPTED FOR FORESTS.

The *forest varieties*, namely, those trees which are generally met with, should live in compact groups; this faculty is more or less developed according to the species of the plant. Certain varieties have the property of forming immense forests and of being maintained indefinitely. Others, on the other hand, are only scattered among other woods. The first have received the name of *dominating* varieties, and the second that of *secondary* varieties.

From the point of view of the natural richness of the soil, the principal forest species of our (*i.e.* the French) climate come in the following order:—

Beech, fir, elm, ash, maple, yoke-elm, oak, pitch pine, alder, lime, hazel, willow, larch, poplar, aspen, birch, and pine.

If account be taken of the artificial enrichment of the soil, the classification is as follows:—

Elm, ash, yoke-elm, alder, forest pine, maritime pine, laricio pine, oak, lime, beech, fir, birch, poplar, larch, and pitch pine.

The degree of humidity required by trees is the reason of their being classed in the following order:—

Alder, mugho pine, ash, "Lord" pine, willow, elm, pitch pine, yoke-elm, oak, marcescent willow, maple, fir, beech, larch, poplar, birch, and pine.

The varieties giving the best yields, according to the nature of the soil, will now be given:

Compact and Pottery Clay Soils.—Pitch pine, alder, ash, poplar, aspen, pedunculated and English oaks, acacia, and small-leafed lime.

Inundated Peaty Soils.—Common alder, birch, black poplar, bird-catchers' sorb, willow, and mugho pine.

Marshy Wholesome Soils.—The preceding varieties, to which must be added the poplars, limes, and "Lord" pines.

Moving Sands.—Maritime and forest pine, acacia, sea-buckthorn.

Dry but Fixed Sands.—Varnish-tree of Japan, birch, St. Lucia wood, white mulberry-tree, maritime pines, "Lord" mugho, and sylvester pine; poplar, aspen, birdcatchers' sorb, acacia, willow, lime, sylvan elm.

Calcareous and Chalky Soils.—Black pines of Corsica; forest pine, beech, service-tree, evergreen oak, marcescent willow.

As a rule, trees improve the soil they occupy. In this respect they may be gradually classed as follows :—

Beech, black pines, both Corsican and sylvester ; larch, fir, pitch, hazel-tree, yoke-elm, maple, alder, ash, oak, aspen, and birch.

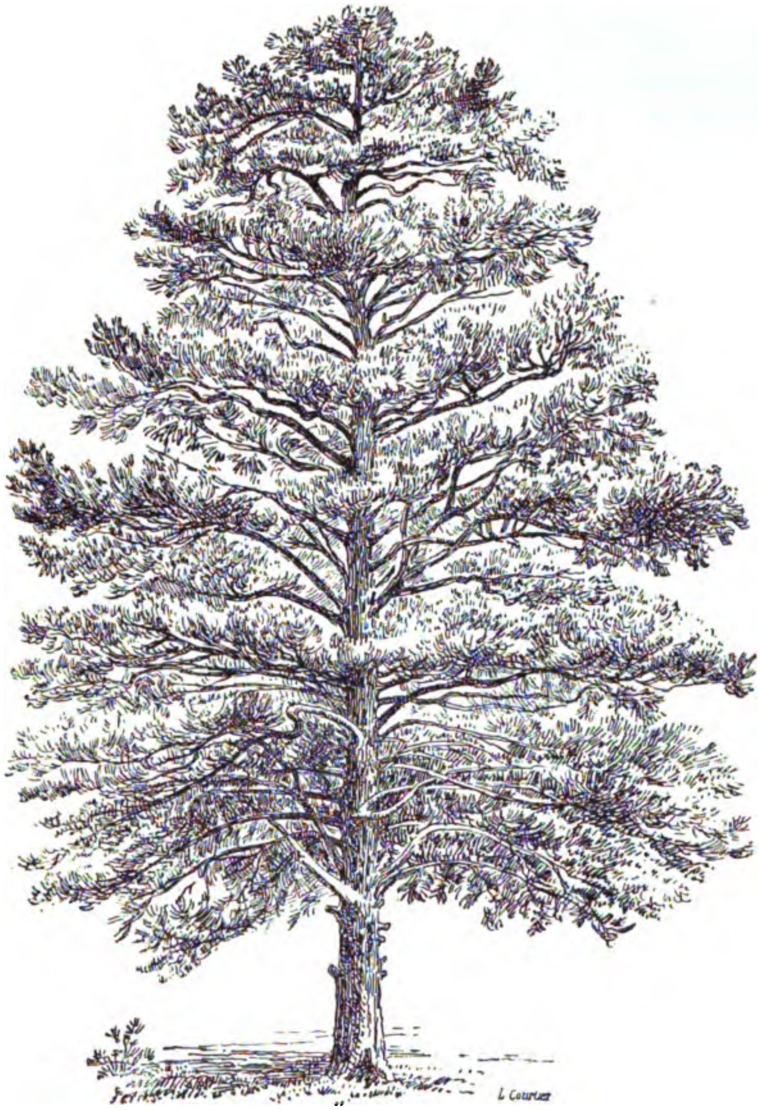

FIG. 112.—Sylvester Pine.

If, however, those varieties are sought which are the least sensible to climatic variations, they are found in the following order :—Birch, cembro pine, birdcatchers' sorb, mugho pine, hooked pine, larch, pitch, forest pine, aspen, poplar, alder, marcescent willow, hazel, lime, ash, oak, maple, beech, yoke-elm, fir, elm.

Most trees like heat and the sun; however, the fir, beech, ash, maple, elm, and pitch prefer the shade. On the other hand, the forest pine, oak, birch, and larch grow better in full light.

IDEAS AS TO ARBORICULTURE—LOPPING.

The science of arboriculture has for its object the fixing of rules which must be followed in order to wood waste and uncultivated land, to restock the glades, and modify existing woods in the hope of arriving at a more profitable exploitation.

Artificial restocking may be made in a variety of ways. The necessary plants can be brought up even upon the place which is to be wooded, or they may be brought from elsewhere and planted upon the ground which is definitely to receive them.

The first manner of procedure is called *semis*, the second *plantation*.

Artificial restocking is very often preceded by indispensable preparatory works—for example, purifying the soil or preparing it specially. A few words will now be said with regard to this.

PURIFYING THE SOIL.

The question of the rendering of the soil wholesome is rather complex. Turf-pits, for example, become sterile if completely drained.

A soil which is too damp for certain varieties, such as the oak, forest pine, and larch, will, on the other hand, be too dry for the alder and willows.

Damp soils can be, and generally are, made wholesome by the aid of uncovered ditches, which must have a uniform slope, to avoid being choked up and deteriorated. The slopes of these ditches are differently inclined, according to the nature of the soil; for strong trees, the inclination varies from 35° to 45°; for argillaceous earth 50° are generally adopted. When the soil is sandy, the inclination is even more.

It is the volume of water to be evacuated and the slope of the bottom which permit of the determination of the breadth and depth of the ditches. On the other hand, the slope must be sufficient to overcome the resistance of the movement of the water.

As to the direction, it is the natural course of the stream and its source which determine it.

In all cases, draining ditches must be established in such a manner as to take the water at its source and conduct it outside.

Fixing of Movable Sands.

This is the second preparatory work, which is often indispensable, and which must be done in the case of special soils, like the moving sands of seashores.

These sands, generally composed of very fine grains, are very powder-like. Their heaping up on our coasts constitutes what are called *dunes.* These sands are very mobile, but the dampness of the atmosphere and that of the soil may render them fertile if they can be rendered immovable.

The work of fixation differs according as to whether the dunes of the shore or those of the interior of the land are in question.

The modes of fixation generally consist at first of continuous palisades, made either with planks or fences. The palisades form the first obstacle to the invasion of the sands of the shore. More in the background upon the top of the dunes fences are established which break the action of the wind, whilst permitting the sands to cross them.

Behind the first palisades, upon a zone about 300 metres broad, where ligneous vegetation is destroyed by saline emanations of the sea, the surface is fixed by sowing herbaceous plants, notably the *gourbet* and the *reed of the sands.* In the zone farther removed from the sea-shore small forest trees are associated with these plants, whose strong rooting better withstands the violence of the wind. In the first line may be cited the *Willow of the Sands.* Then, when once the sands are fixed, the sea-buckthorn, furze, caragana, etc., are planted there.

Those varieties which are the most highly recommended are the following:—Poplars, birch, false acacias, varnish-tree of Japan, typhina, etc. But the best species, as will be shown a little further on, are undoubtedly, for the northern dunes the forest pine, and for those of the south and west the maritime pine.

Lopping.

An interesting portion of arboriculture is that which treats of the care to be bestowed upon the trees of a forest during their growth. Forests left to themselves, indeed, do not give anything like the yield that is expected from those trees which comprise them which have been methodically attended to. Messieurs de Ceurval and des Cars have formulated some rules upon this point, and especially upon tree-lopping, which may be repeated here.

The problem to be decided upon consists in not allowing the sap to be uselessly expended in the forming of branches of little value, but to

concentrate as much as possible its action for the ligneous formation of the trunk, which is the industrial part of the tree, and, consequently, to hasten the production of timber of good dimensions adapted to trade. It is by judicious and reasonable lopping that this problem has been solved. But lopping leading to the ablation of certain branches may bring on brown-rust, and therefore, to avoid this great inconvenience, certain special rules must be observed.

Lopping is the only means of concentrating the ligneous formation upon the trunk. It is hence necessary that the sap should arrive as quickly as possible in the trunk, and that afterwards, in its transit, descending from the leaves to the roots, the passage along the trunk should be as rapid as possible.

To attain this result, it is necessary, by judicious pruning of the tree, to reduce as soon as possible its branches in a horizontal direction, at the same time preserving, upon the leafy surface, the necessary development; it is known, however, that the nearer the branches are together in the vertical direction, the more they develop, to the detriment of the trunk.

Consequently, by preserving in a vertical direction only the trunk and the main stem, their development in size is favoured, and by reducing the branches in a horizontal direction, the formation of the wood upon the trunk can be traced rapidly.

But as the tree grows higher, a time will come when the leafy surface will be too considerable in proportion to the development of the roots, which furnish the leaves with sap. To avoid this inconvenience, which would produce a defective vegetation, the practice is to take away the lower branches, in order to always preserve a perfect equilibrium between all parts of the tree. It therefore follows that one must conform to the following rule :—

The top of the tree must have an ovoid form, narrow horizontally in proportion as the tree is younger; the height of this ovoid should vary from two-thirds of the height of the tree for the young trees to one-half for older trees.

In all of the suppressions of the branches to which one is led by the application of this method, there are very simple precautions to be taken to avoid brown-rust.

Instead of cutting the branches at a certain distance from the trunk, as is most usually done, it is necessary to cut them vertically and quite level with the trunk, doing this so that the wound unites as well as possible with the sapwood. The section thus operated on is then covered with coal-tar. The simple fact of the vertical section and at the level

of the trunk will, in many cases, where the wounds are small, lead to the healing of the wound; but one is never sure of avoiding the brown-rust, and the danger increases with the dimensions of the wound. Whilst in covering the wound with coal-tar there is never brown-rust, the covering of the wound by the new wood is far more rapid, and the void remaining between the wound and the new wood is not so great.

If a branch is cut a little farther from the trunk, rust forms at the base, which hardens very quickly, and there the sap soon no longer circulates, so that the stump of the branch dies and soon falls, leaving a hole which cannot be closed up.

The life of old ulcerated trees can also be equally aided by applying the following treatment to them:—The wound is cleaned with care, coal-tar is passed into it to arrest brown-rust and destroy the insects, then the wound is filled with wood, cement, or some non-hygrometrical matter. Provided that this plug thoroughly levels the squared edges of the wound, and that it is carefully covered with coal-tar, the tree at the end of a certain time commences to grow again.

To continue, the practice of lopping leads to the following results:—

(1) More rapid and regular growth of the trunk, and, consequently, increase of production.

(2) Certainty of preserving the trees from brown-rust.

(3) Suppression of the harmful effects on vegetation caused by the vicinity of trees which throw a thick shade over them.

Let us add that one very important cause of ruin, affecting more than a third of the trees of timber forests, can be prevented by the method of lopping of which we have just given an idea. A few words will now be spoken as to trimming the tree (*la tranche*).

The *tranche* is necessitated by the torsion of the tree during its growth. The torsion of the tree is promoted by several causes, the principal of which is the action of the prevalent wind on the leaves. Trees placed on the borders of forests are particularly exposed to this. Their foliage develops on the side exposed to the air and sun, their centre of figure changes, and their centre of gravity also changes naturally; the prevailing wind then makes them turn. Once commenced, the rotative movement is not arrested, for the same cause incessantly produces the same effect in the same direction, and it is not rare in a period of from seventy-five to a hundred years for a tree to turn completely by itself. Then, the fibres affect the direction of a spiral around the axis of the tree. Cut into beams, this tree is rejected or very seriously affected in its resistance; cut into planks, flaws run all through it: hence its timber is unsuited for joinery.

Even in the centre of a forest a tree will turn, because the lopping, unequally done around its axis, renders the movement of the rotation upon its roots more easy, if the wind penetrates to it. As for isolated trees, they are left to themselves. The leaf, becoming less developed on the northern side than from that facing sunlight and heat, the tree has a continuous rotating movement, under the influence of the prevalent wind. The movement, when once commenced, is invariably kept up.

In giving to the tree, by the lopping of its leafy branches, the ovoid form following a centre of figure passing through the axis of the tree—that is to say, through its centre of gravity—an excellent remedy is adopted to counteract the vice which has just been mentioned, if the influence of the prevailing winds be carefully watched.

IMPROVEMENT AND REGENERATION OF FORESTS—CULTIVATION OF THE PINE.

Three principal causes of ruin act upon forests, namely—

(1) The disappearance of hard timber.

(2) The impoverishment of forests upon slopes.

(3) The havoc brought about by frost.

All these causes joined together and the permanent impoverishment which has been gone on without check for centuries in the largest part of our wooded soil, are more than sufficient to compromise the value of forests when a remedy cannot be found for them.

When the period of the management of forests in the form of copses has been decided on according to calculations based upon the state of the forest and the species with which it is stocked, and when the cuttings are separated between them by well-traced routes, everything prescribed by the ancient principles of sylviculture has been accomplished; but in course of time this forest management no longer finds itself in harmony with the course of Nature, the natural seed-beds are choked, the shoots become exhausted, and degenerate in succeeding each other.

The object to be aimed at should be to bring about regeneration by the substitution of good varieties for those which have become bad.

The difference in the yield of one variety from that of another, in a given time, is considerable. A striking example will be obtained of this if the oak and yoke-elm, which are hard timbers, are compared. In a copse twenty-five years old the volume of the trunk of the first is to that of the second as 14 is to 5.

The difference is even greater if the respective value of these two timbers is compared; it is therefore seen of what importance is the choice of varieties.

It is easy, in groups of high trees, to maintain good varieties, for in the long-run they destroy the others, and the successive clearings accelerate the destruction of the undergrowth. It is not the same with copses in general, and it can be observed that the oak species have diminished, which must be attributed to the following causes:—

The young oak cannot do without shade in its early years, but it does not take long to prove the progressive need of the influence of light and air. However, it is always more and more compressed by the white woods which dominate it, and by the brambles and thorns which rob its nourishment; its seed-beds perish, its shoots degenerate, and it becomes rare, so much so that the wood ripe for cutting can no longer be replaced.

Experience has shown that a copse of oak can be maintained in its purity by extirpating the other species, and by cutting down when they are marketable all those trees which it is desired to destroy. Restocking is afterwards effected with shoots or by planting acorns.

This destruction of the poor varieties therefore becomes indispensable in sylviculture; but as a set-off one must take care in proceeding to the removal of the good species.

It is thus that, returning to the causes of decay which have been already pointed out, it may be said that the only efficacious and certain remedy is to oppose the disappearance of hard woods, and to proceed to the planting of different varieties of resinous trees adapted to the different climates and conditions of the soil.

Thus, in soils where the tendency is for hard woods to disappear, the presence of pines alone, the powerful manure with which they cover the soil, and the protection they give to the neighbouring trees, suffice to arrest this disappearance.

The forests of the Vosges offer some striking examples in support of this statement. Thus it is that in these mountains near lands formerly covered by woods of oak, and to-day overrun by the beech, similar ground is seen, where for centuries the pines, oaks, and beeches have been allied, confused, and seem to struggle vigorously. Far from any of these varieties perishing, it is seen, on the contrary, that under the high trees, numerous seed-plots of oaks and other varieties are developed.

These same resinous trees, planted in forests situated upon slopes, and which perish as a consequence of the poorness of the soil, leave

their cones on the ground, which rot in the grass and form an abundant manure, whilst their compact branches, neutralising the action of wind and sun, keep the soil in the constant state of humidity and porosity indispensable to active vegetation. The pines themselves,

FIG. 113.—Fir-Tree.

profiting by the fertilising agency of the cones which they drop in profusion, rapidly develop their branches, encircle laterally all the neighbouring trees, and force them to grow vertically.

In this manner shoots are transformed into forests of high trees, which, without the presence of the pines, would have remained puny and

stunted. Hence the reasonable introduction of resinous trees into the midst of copses would soon make a quantity of important forest-trees spring up, even from the most sterile land.

If we pass to those soils which are exposed to the effects of frost, the intervention of the resinous tree may, even there, produce considerable effects.

Now, when it is decided to introduce pines for the improvement or regeneration of a forest, it is necessary to know how to study with care the nature of the land to be wooded; very often the seed of the maritime pine has been entrusted to soils where it would have been better to have sown the forest pine.

The maritime is not very delicate, and grows upon almost all soils, it is true, but with very great differences, according to the degree to which the soil suits it. In Sologne maritime pines have been successfully planted, and a little distance away these same pines are meagre, elongated, and sorry-looking; some can be preserved for sixty years and more, others will not even reach twenty-five years, and often much less—and this upon land which is, in appearance, of the same quality. Some have a foundation, the roots being able to force themselves into it, the tap-root especially; others rest upon tufa, more or less argillaceous and impermeable. In these latter soils the tap-root does not assume any strength; the tree lives by its lateral roots, and these are obstructed by neighbouring ones. Then, when the earth is soaked by heavy rains, if very windy weather follows, the pines are blown down.

From all these considerations it follows that every proprietor who wishes to transform his lands into nurseries must study his soil; one nursery often differs from another to the point of even having a value twice or three times greater, not only by the productive quality of the soil, but also by its constitution, depth, nature of the under-soil, and its hygrometrical condition.

To make seed-beds of maritime pines it is sufficient to prepare the ground by a slight tillage, and to use 15 to 20 kilogs. of seed per hectare (1 hectare = $2\frac{1}{2}$ acres).

The maritime pine is often sown in cord-land, upon a stubble-field or among buckwheat. The presence of broom is often an indication that the ground, at least at the surface, suits maritime pines.

The under-soil remains to be studied, for it is upon this that the future and complete success of a nursery depend.

Wherever the earth is tenacious, clayey, covered by thorn-broom or large furze, the maritime pine must not be planted. These lands, on the

contrary, suit the sylvester pine marvellously well; it frees itself much better than does the maritime pine from coarse grass, furze, and thorn-broom; it dominates and chokes them under its powerful branches, and supports the confined position better, resisting strong winds better than the maritime pine.

The seed-plots made and the gathering successfully effected, there only remains the important question of clearing the escarpments, for upon this work depends the future of the nurseries, which, in order to produce fine trees, should be most carefully attended to.

At what age should the seed-plots be utilised? Some say in the third or fourth year, others in the eighth, ninth, or tenth.

In the third or fourth year the work is costly, and does not yield much. In the eighth, ninth, or tenth year fagots are made, it is true, and a slight produce is extracted, but this is at the expense of the future. The maritime pine, like all the conifers, lives partly by its leaves, and must therefore be provided for in some measure.

In the first thinnings, which are done in the eighth, ninth, or tenth year, the pines are from 15 to 23 in. high; when they are too crowded, the top only is provided with leaves; when they are isolated, they are provided alone with a crown which rises from 12 to 19 in. and sometimes 23 in. from the ground. When the thinning is done in the third or fourth year, though it is very advantageous for the future of the plantations, it is unprofitable at the time.

Moreover, in the third or fourth year the seed-plots of maritime pines are still in an herbaceous state, and, in sandy soils, they are easily pulled out by hand or very easily with a flat pickaxe. One man can thin from 30 to 45 ares in one day, in spacing the trees from 19 to 27 in.

In this state the young pines not only form and extend their top, but preserve, some a crown, others two crowns, according to the more or less confined and primitive condition of the seed-plots.

Young pines, thinned at this age of the superfluous trees and well spaced out, as already said, assume a conical form, giving them strength to resist winds. They continue to grow all the better, more especially as, in proportion to their age, they are furnished with branches as well as those thinned in the seventh, eighth, or ninth year.

If this operation is carefully repeated every three years without ever cutting off the crown, the thinning must be rather carefully done, so that the bringing of the pines nearer to each other will clear the branches from the lower part, in proportion as those of the upper part are formed, so that a third only of the height remains provided with branches. In other words, the thinning must be regularly conducted, in such a

manner that all the pines meet without actually touching each other, for although light is necessary it must not be too abundant.

By these successive thinnings, pines are obtained which are worth, at fifteen or sixteen years, more than some pines of twenty or twenty-five years where the thinnings have been carried out with less care.

We will not leave this subject without mentioning the remarkable results obtained, forty years ago, by M. Chambrelent, in the heaths of Gascony, until that time renowned for the agricultural unsuccess of which they had always been the scene.

The Landes of Gascony form a vast plateau of about 2,000,000 acres, slightly sloped and situated at a height of from 130 to 195 ft. above the level of the sea.

The soil, which is of absolute uniformity, is composed of a layer from 23 to 31 in. in thickness, formed of pure, siliceous sand, white and very fine, scarcely coloured by the detritus of plants which vegetate upon the surface, only containing slight traces of clay and calcareous matters.

The under-soil, known in the country under the name of *alios*, is a bed from 12 to 19 in. in thickness, of this same siliceous sand, agglutinated and rendered impermeable by a sort of organic cement. Underneath the *alios*, a fine sand constantly impregnated with water is found, at an indefinite depth.

Rain-water finding no outlet and being unable to sink in the soil, remains stagnant there during the winter, until it is evaporated by the heat of summer. Thus a permanent inundation during the winter and an absolute desert of burning sand during the summer is the general state of this vast desert where it is not cultivated.

Under such conditions ordinary culture is impossible, and the forest varieties cannot prosper, for the dryness does not take long to burn what the damp has not rotted.

M. Chambrelent understood that it was necessary to first get rid of the stagnant water—that is to say, that all improvements in the heaths must be preceded by making the land wholesome and healthy. This problem has been solved by a very simple and economical method, without having recourse to drainage, which was too costly as compared with the value of the soil.

There is throughout the whole plateau of the Landes, from the top to the slopes of the valleys, a very regular and general slope; at no point does the land form a basin which would necessitate the labour of digging channels for the water. The slope is so very slight that the slightest impediment or the ordinary irregularity of the ground

stop the water and prevent it from following the declivity. But these irregularities, which thus fetter the natural draining, are never more than 12 to 15 in. high; thus if, upon any point whatever of the heath, a ditch is opened from 15 to 19 in. deep, the bottom of which is just deep enough to run parallel to the general slope of the ground, it is certain that this ditch could be made throughout its whole extent, without the necessity of clearing more than 23 to 27 in. deep, and this would carry away any water which may come there. Traversing, moreover, a very permeable and sandy soil, it attracts to itself the superficial waters, even from a rather long distance, and as the slope of this ditch never exceeds 3 mm. per metre, the water runs there regularly without wearing away the banks.

Experience has shown that 400 current metres per hectare, of ditches 1·20 m. wide at the top and 40 cms. deep, following the most extreme slope of the ground, were sufficient to assure a perfectly healthy soil.

Before the works which have been done in accordance with the principles that we have developed, the heaths were completely inundated. The effect of these ditches, producing a perfect drainage of the rain-water, was complete and immediate.

Ditches not only serve to assure the making of the soil wholesome, they also offer the advantage of favouring the aëration of the groups of plantations and of arresting the spread of fire.

The ground thus made wholesome can be cultivated for almost any purpose. But in a country where the soil is composed of pure sand, without mixture of calcareous substances and clay, and where manure and population are absent, one cannot think at the outset of the cultivation of cereals. One is also limited, in the lands thus made wholesome, to seed-plots of oaks and pines, which are the two most suitable varieties, having the advantage of assuring for the future very beautiful and remunerative products.

Before it was made healthy, all the seed-plots of oaks did not succeed, because during two months of spring, at the time of natural germination, the solar heat was entirely absorbed by the water covering the soil. It was hardly until towards the middle of June, or at the most at the end of May, that the ground, freed of winter rain-water, received the warmth necessary to the plant. The acorn then sometimes germinated well, but with trouble and very slowly; then, when the heat of July came, the plant, which was hardly growing yet, could not withstand the heat of the sun, and died in July through not having grown in April.

As regards the pines, the evil was not so great; they resisted the

heat of summer better, but their vegetation always suffered greatly, and their development was even impossible in several places.

On the other hand, the acorns and seed of the pine sown in well-matured ground can germinate everywhere in March under the influence of spring rains, which only traverse and water the ground, and of the sun, which is already warm at this time.

In July the young plants, which have promptly thrust their roots into a light and very divided soil, are found strong enough to resist the sun's rays and to commence active vegetation in the early days of the following spring.

From the point of view of the commercial advantages which have resulted from this method of cultivation, it may be said that in the last few years the exportations furnished by the products of the forests of the Landes have been enormous.

It is principally posts for mines and telegraphs, and railway sleepers, which constitute this important commerce.

In the seven years preceding 1884 the average of the exportation of mining posts in England was 180,000 tons; in 1884 it was 210,000; and in 1886 it reached 250,000 tons.

The forests of the Landes extend over an area of 2,000,000 acres, with an annual production reaching 3,000,000 tons.

The pine sleepers are less liable to crack under the influence of heat; they are also greatly used for the construction of railroads in Spain, Algeria, Tunis, Senegal, Panama, etc.

The timber of the Landes could also find a good outlet as firewood in Parisian bakery establishments.

The ovens of Paris consume 600 tons of wood daily. Until the severe winter of 1880 Sologne principally supplied this wood, but to-day a great part of it comes from Germany.

For street-paving, the pines of the Landes can compete with the timber of Sweden, solely employed for this purpose; recent experiments show that they are not inferior in resisting powers to the timbers of Sweden.

CHAPTER XIV.

CLEARING AND REPLANTING—PRESERVATION OF FORESTS.

THE forests which still exist in Europe, and notably those of France, are the remains of immense groups of trees which formerly stretched uniformly over the larger portion of its territory.

Gaul evidently receives its name from the Celtic word *Gaël*, signifying forest. The larger parts of the Iberic peninsula and of Italy were also covered with timber; and if, in this latter country, clearings were made in the early ages, in Gaul, on the other hand, and in Spain the land remained for a long time in the state of virgin forests, in the glades of which lived the savage tribes.

Druidic tradition has preserved the memory of this primitive state of the land, and relates how a fire, caused by lightning, at once altered the surface of the country.

"Lightning," says the legend, "fell from the summit of the Pyrenees; the flame caught in the heap of resinous branches with which the soil was covered, making a clear fire which immediately set the forests ablaze. The fire directed its ravages on one side over Iberia and on the other over Gaul, following the chains of the Cevennes, Gevaudan, Charolais, and Vivarais; thence the fire spread over the plateau of Langres, where the fury of the flames invaded on the one hand Jura and the Vosges, and on the other the Alps as far as Eridan, where the fire ended."

The oases made by the fire in the midst of the compact mass of forests were then invaded by colonies of people from Germany, which was also, at this time, nothing more than a vast forest.

This state of things lasted until the time of Cæsar; then, for the security of the conquerors, for the establishment of new towns, and for the nourishment of men and troops, vast clearings were commenced.

However, at the end of the Roman domination one could still cross over Gaul, from east to west and north to south, following uninterruptedly large bands of primeval forests. But in proportion as the population

increased and communities were formed, there happened just what has happened in America in modern times: these large zones of forests were attacked from all sides and from all sorts of motives, sometimes because they were an obstacle to the cultivation of cereals, sometimes because the wood was required for various purposes. It is in this manner that these last remains of our large wooded groups, like those islands that the ocean consumes without cessation, disappear continually under the effects of the ever-increasing tide of population.

The causes of the grubbing up or destruction of forests—in a word, of the "clearing"—are multifarious. The progress of civilisation and increase of population have just been cited, but there are besides war, fire, abuse of pasturage, carelessness, the passion for destruction of some country people, and, lastly, certain political, financial, or administrative measures.

But if only those of the causes are considered which result from a rational order of things—from the need of creating new arable land, for example, or from the desire of drawing from the soil the largest possible profit—it will not be found that the clearings have everywhere been conducted with equal discernment. It is in the most enlightened countries that the value of the soil has been best recognised, and where they have abstained from clearing the land which is only fit for forest cultivation.

There is no doubt that there are some favoured countries where arable and good land is everywhere found: these are the plains generally; all the plains, however, are not in this reckoning, for Sologne—that immense, dry, marshy, and feverish plain, formerly covered with forests—presents us with one of the most regrettable and fatal results which inconsiderate clearings may produce.

Most frequently, in even the most fertile regions, there always exists a certain extent of land of inferior quality, to which forest vegetation seems to be better appropriated. The forests which are found there must evidently be preserved with the greatest care, since sterility alone can be substituted for them. This is what has generally been done in enlightened, rich, and advanced countries; on the other hand, it is not what has been done in sterile, poor, and backward countries, according to all reports.

If England is taken, for example, it is found that, of all nations, it is she who makes the greatest efforts for the good administration and preservation of her forests.

Her forest domain only exists in her colonies—but with what care and precaution does she guard them! Forest-rangers learn all they can

in the schools of France and Germany; they do not recede before sacrifice of time and money to attain the object they have in view.

In our country (*i.e.* France), going back only a hundred years, we find that in 1797 de Neufchâteau, then Minister of the Interior, addressed a circular to the central administrations of the departments, in which he states "that for a century the consumption of wood in France has exceeded its production; that the evil increases day by day; that the too frequent clearings, especially in the high lands, the growth of population, the increased consumption for buildings and furnaces, or the bad construction of the latter, have caused a famine of timber of the most alarming description." And he adds that one of the first cares of the Government should be to equalise, as much as possible, the consumption and reproduction of timber.

Before him, Turgot, following the opinion of Buffon and Réaumur, directed a decree to compel owners to plant a twentieth part of their land, under penalty of a fine.

Since then—thanks to the law of 1860 as to the replanting of mountains and putting to profitable use marshes and uncultivated land belonging to communes—plantations multiplied everywhere; heaths, mountains, and communal lands were sown and planted, and the State forests were restocked and attended to with care and perseverance. France will thus be able to face the crisis with which it is threatened by the exhaustion of its coal-pits, and with all the more necessity as, in the present state of things, these pits only produce half of the coal necessary for consumption.

The clearing of a country has not only an influence upon the climate, but it also modifies the flora and fauna of a country. Upon the banks of the Rhine, several hundreds of years ago, the vine was cultivated upon a large scale; it has partially disappeared, however, because, as the vineyard owners say, "it has lost the shelter of the forests."

In modern times the State takes the forests under its protection, at other times they were under that of the gods. Certain trees were the objects of veneration, and many forests were considered as natural ramparts against the ravages of avalanches and ravines. As has been seen, they not only prevented the formation of them, but they even stopped them, so that nothing better has been found, to make certain places habitable, than to rewood the neighbouring mountains.

It is the plantations alone which have fixed the dunes of Gascony; and these same plantations have prevented the mountains from falling in avalanches and filling, in time, the valleys.

With reference to the clearings, de Humboldt says in *Cosmos*:

"The clearings on the mountains will lead to two great afflictions for future generations—*the want of caloric* and *the want of water.*" He adds that "the strong transpiration of the leaves spreads great dampness in the air, which is carried by the wind great distances. Forests give, besides, to the lands that they shelter, a protective covering, and delay the flowing of rain-water; the streams are naturally maintained in their normal condition; the flowers do not get dried up, and the cultivator of the plain may depend upon the neighbouring mountains for the irrigation of his ground."

In pursuing the subject of clearing, de Humboldt again says: "River beds, which remain dry a part of the year, become changed into torrents when it rains. The grass and moss disappear with the ligneous vegetation; the millions of leaves which imbibe the humidity disappear with the trees, and the rain-water is no longer retained in its course. Instead of increasing by degrees, very slowly, and by infiltration, the water issuing from the melting of snow or from rain is precipitated from the mountains, forming torrents which bring down into the valleys the earth which they carry with them, thus causing inundations."

To anybody who has traversed the French Alps (at the present time almost denuded) and the Swiss Alps (where the forests have been better preserved) the effects of clearing are manifest. In the French Alps there are numerous courses, usually dry in summer, which, upon the melting of the snow and in stormy weather, become turbulent streams. In the Italian Alps, on the other hand, the streams do not generally become large enough to cause great floods.

In considering the influence of forests on the *régime* of water we will point out the impediment that they put in the way of avalanches. Many highland villages only owe their preservation to a forest, whose trees arrest this dreaded scourge. As a particular instance the village of Andermatt, in Switzerland, can be cited. Its existence depends upon that of a forest of fir-trees, covering a slope which is ravaged each winter by avalanches. This fact is recognised to such an extent that the felling of trees is forbidden under the severest penalties.

Forests exercise another action, not so well defined perhaps, but still more important, if a clearing is considered only in a particular locality. We refer to the destruction of miasma. The production of malaria is favoured by the decomposition of animal or vegetable matters, which occurs in marshy countries, such as marshes celebrated for their unhealthiness. Forests appear to exercise a destructive action over the miasma, and certain countries—Sologne, for example—have become unhealthy owing to clearing the land of trees.

The example of the small town of Chantilly may here be cited, which is never visited by cholera, whilst the village of Montataire, situated at no great distance, but quite outside of the forest, is always attacked first when the terrible scourge makes its appearance in the Isle of France.

M. Becquerel, in discussing the important question of clearing, has arrived at the following conclusions :—

(1) Large clearings diminish the quantity of spring water flowing in a country.

(2) It cannot be decided whether this diminution should be attributed to a less annual amount of water fallen or to greater evaporation of rain-water, or to these two causes combined, or to a fresh dispersion of the rain-water.

(3) A plantation in a dry and open country consumes a portion of the running water.

(4) In those countries which have not undergone any change in cultivation the quantity of spring water always appears to be the same.

(5) Forests, whilst preserving spring water, husband and regulate its flow.

(6) The dampness which exists in forests and the intervention of the roots to make the soil more permeable must be taken into consideration.

(7) Forests in mountainous countries exercise an influence over water-courses and streams; in plains they only act upon the springs.

In concluding this part of our study as to the evil influence exercised in our country (France) by clearing, we may quote the conclusions which can be drawn from an examination of the forest map of France. It may be said that clearing is very unequally carried out over the different natural divisions of France studied in its *ensemble*. Contrary to the previsions based on geological and mineralogical conditions and on the well-known propensity of forests to continue to spread, it is where agriculture has ceased to be profitable that the valleys and their water-sheds have been least deprived of their trees; whereas the great trees standing alone or in groups in the plains or in the high lands have been almost completely cleared, especially in the central districts.

The necessities of consumption, the bulky nature of timber, and the difficulty and high price of transport, have in a large measure brought about this result.

But it is noticed, on the other hand, that in each basin, separately considered, the division of agricultural and forest production is quite logical, perfectly subordinated to the geological structure and to the mineral

composition of the soil. It is seen, that with few exceptions agriculture occupies all the fertile lands, that sylviculture occupies those lands only which, without its co-operation, would remain consecrated to sterility, namely, sandstone and siliceous sands, calcareous substances, and the crests of hills and slopes. It can, at any rate, be concluded from this examination that to the slightly fertile regions and to the poor and unenlightened populations correspond the unwooded and unproductive regions, and that a *wooded country* spells a *prosperous country*, and that when we say an *unwooded country*, we say a *poor country*.

Let us add that it would be inexact to say that iron, with its various uses in building, could act as a remedy for the *déboisement* (clearing) of territory, for it has been proved, on the other hand, that the consumption of timber has never been larger than since the generalisation of the employment of iron.

It is therefore incumbent on civilisation to attend to replantation, the more so as it takes a considerable time before the tree becomes of service from an industrial point of view. The following table shows the average age of the different forest varieties at the most advantageous time of felling:—

	Years.
Common walnut	250 to 300
English oak	250
White oak	200
Common chestnut	200
European lime	125
Dutch lime	90 to 100
Beech	90 „ 95
Elm	90 „ 100
Forest pine	90
Sycamore	50
Elm, poplar, birch	50 to 60

These are well-established facts, namely, on the one hand, *the necessity of preserving and improving the forests which remain*; and, on the other, *the expediency of replanting elevated and poor countries, not only on their own account, but to improve the valleys.* The means and processes most easily leading to the attainment of this last result will now be treated.

REPLANTING.

The Law of 28th July 1860 as to replanting, and that of 8th June 1864 as to the turfing of mountains, have given to all the questions referring to the different modes of restocking a great impulse, which has been fruitful in results.

As a consequence of the terrible inundations of 1856, public opinion unanimously indicated that the rewooding of the mountains was the most certain means, if not to prevent a recurrence, at least to attenuate the terrible consequences of them.

From 1861 the work was commenced. Since then, the numerous studies which have been made, the valuable observations collected, and the undeniable and striking results which have been obtained have victoriously replied to the early objections.

The successive accounts published by the Administration of Forests have made known the degree of advancement of the labours, their success and expense. Upon every point of the mountainous regions of France where replantings, whether optional or obligatory, have been undertaken, the young forest existing to-day presents and maintains the most categorical refutation of the preconceived allegations which had refused to it the possibility of being born, living, and becoming developed.

In the high regions of the Alps—that classic land of torrents—numerous plantings of resinous varieties may be seen to-day, adapted to the local climate, sending forth their vigorous vegetation, not only in the receiving basins of the floods now prevented by the works, but even upon their always protected and fixed banks; whilst these torrents themselves, formerly so dreaded, have become not only inoffensive streams, but all the more precious as they supply agriculture with better and more abundant irrigation water.

Thousands of acres are to-day rewooded. Disseminated over the whole extent of ground forming the basins of the torrential water-courses, these plantations comprise a vast defensive system which as it becomes completed gradually regulates the streams.

But to provide for these plantations enormous quantities of seeds and plants are necessary.

However, the State has established, since the law as to replanting, certain drying establishments where the seeds gathered close to these works are directly prepared. Algeria also provides an important quantity of seeds of the Aleppo pine and cedar.

As for the plants, they come almost entirely from the nurseries specially created by the State in view of the work of replanting.

Among these nurseries, some, called *volantes*, are established close to the future plantation; others, more considerable, are permanent. In this way supplies of plants of all sorts are prepared on a vast scale.

With regard to the forest varieties adapted for plantations it may at once be said in a general manner that the sylvester pine, pitch pine, and larch are the three varieties whose employment, in mountainous

regions, has been most extensive since the coming into operation of the law as to replanting.

Other varieties have been successively introduced into the restockings in proportion as new experiments have been attempted.

The oak is planted everywhere where the conditions of soil, climate, position, and altitude appear favourable to the development of this valuable variety.

The Austrian black pine, specially adapted to calcareous soil, is successfully employed in a great number of districts.

The hooked pine, whose vigour permits of its being planted in the most rigorous climatic conditions, is employed in high portions of the Pyrenees, the Alps, and the mountains of the centre.

The Aleppo pine, the variety *par excellence* of the mountains of Provence, succeed very well in the South.

The cedar, sown on different points of the Alps, Auvergne Mountains, Cevennes, and Pyrenees, grows there with remarkable vigour.

The ailanthus, planted at a moderate altitude, appears to give equally good results, by reason of the very pronounced shooting property of its roots, which retain the earth upon the slopes.

Among the foreign varieties whose naturalisation appears to be carried out with success, may be cited the Nordmann fir, cedars, the Pinsapo, bald cypress, Wellingtonia, *Thuja gigantea*, eucalyptus—this last has been successfully grown upon the mountains surrounding Nice, in Corsica, and especially in Algeria.

Some details will now be given of these different forest varieties fit for replanting purposes according to the respective climatic conditions.

(1) Warm Region.

The Aleppo pine, very extensive in Algeria, forms very extensive forests there, covering thousands of acres.

Provence, where it assumes the name of white pine, contains it in large quantities, principally upon calcareous slopes. If the position is warm, it may flourish even at an altitude of about 2200 ft.; in the opposite case it will not grow above an altitude of 1300 ft.

This variety is the most valuable for replanting; it grows even in the worst soil, and braves easily the heat of the sun.

The plantation of this pine produces in a short time complete groups in the poorest and most sterile soil.

Moreover, this tree furnishes a thick covering, for its trunk is

provided with numerous branches, and the neighbouring soil is rapidly increased by the decomposition of its long and abundant needles.

It grows rapidly, but it has a short life, and must be utilised towards the twenty-fourth year.

The wood of this variety is fine and compact, but more brittle than that of other resinous varieties. It is preferably employed in the manufacture of packing cases.

The resin which is obtained from it is of excellent quality, and the warmer the climate the more abundant is it.

This tree can be very easily intermixed with other varieties, especially the evergreen oak.

The Aleppo pine is employed for plantations, whether by the medium of seeds or slips.

The maritime pine occupies vast stretches of forest in Provence, Languedoc, and Landes. It is also met with in Brittany.

This tree favours especially siliceous soils and those belonging to volcanic formations. It is also found in the Maritime Alps, upon calcareous ground, often mixed with the Aleppo pine. It succeeds equally well in soils with a calcareous base by means of artificial restocking, but it especially requires a light soil.

It will always be expedient to give preference to the maritime pine in siliceous and volcanic soils and to reserve the Aleppo pine for those soils where calcareous matters abound.

The maritime pine, which has less foliage, and is straighter than the Aleppo pine, does not endure dryness so well as this latter. Like it, it supplies the soil with an abundant manure, the age at which it can be utilised being the same.

Resin is the principal product of this variety. The presence of the resin does not diminish the qualities of the wood; on the contrary, it increases its durability and resistance; it is harmful to the growth of the trees, however, and deforms them.

The maritime pine serves for the same purposes as the Aleppo pine, though its dimensions are not so great.

Planting it with the cork-tree succeeds better than with the evergreen oak, because it prefers volcanic soils, which also improve the timber of the oak.

In replanting, the maritime pine is employed more frequently as seed than as young trees, because, on the one hand, its seed is of moderate price, and, on the other, its tap-root, which is not so fibrous as that of the Aleppo pine, presents more risks in plantation.

As for the *evergreen* or *holm oak*, this variety ordinarily forms in

France simple coppices, cut for sale at rather short intervals. Forests of evergreen oaks are not met with. However, large but isolated specimens of this tree are found.

The species called by the Algerians *ballote* supplies sweet, comestible

Fig. 114.—Oak.

acorns, supplanting the chestnut. This variety, which is rather rare, is found in Provence.

The evergreen oak is far more widespread than the Aleppo pine; it is found along the shore of the Bay of Biscay as far as the Loire,

In the Maritime Alps coppices of evergreen oaks are met with at an altitude of about 3900 ft. in warm positions, but in the interior their altitude does not exceed 2000 ft.

This tree prefers calcareous soils; at low altitudes, in volcanic ground, it is replaced by the cork-tree. This is a valuable variety for plantations, and its covering, which is very thick, gives to the surrounding earth constant freshness. Its growth is slow; its timber, which is very hard, is largely utilised in commerce.

The coppices give a very good firewood, and its bark is highly valued.

In planting the evergreen oak, young trees cannot be utilised on account of the great length and nudity of the tap-root. For this variety one is compelled to have exclusive recourse to seeds. But the fact of its having a very long tap-root renders it suitable for preventing landslides in sloping ground.

The **Cork-tree**, as has already been seen, is very common in Spain and Algeria; it belongs to the flora of the Mediterranean.

It is especially upon the littoral, at altitudes not exceeding 2200 ft. in warm positions, that it is met with. It forms important groups upon soils generally fertile, produced by the disintegration of volcanic rocks. Its employment for planting purposes is very limited by its exigencies, though it is necessary to take account of its products, which are very valuable.

The growth of this tree is at first very slow, then at the age of six years it commences to quicken.

As for the preceding varieties, it is preferable to use seed-plots rather than to transplant.

This special point will be more fully dealt with further on.

The **Carob-tree** (Locust) is met with in France upon a part of the littoral of the Maritime Alps. It also grows in the vicinity of Toulon, and in these places some beautiful specimens of it exist.

It is never seen in groups; without actually becoming very large, it often attains a good size.

All soils suit it, with the exception of marshy or sandy ground. Rocky and dry soils suit it admirably.

The covering of this tree is very thick, and its leaves are persistent. The fruit is often used as a nutriment for horses; the timber, which is hard and compact, is employed in cabinetmaking.

The growth of the carob-tree is very rapid. Its employment in the rewooding of bare land has given excellent results in Algeria and the Maritime Alps.

The **Fir-cone Pine** grows principally upon the littoral of the Mediterranean, where it often forms isolated clusters, presenting itself in the form of specimens remarkable for their height and diameter.

In Provence it has received the name of *kernel pine*; its seed, which is very large, is comestible.

It is most frequently found at the bottom of valleys, though it can adapt itself equally well to dry and rocky soils.

The growth of this tree is rather rapid, though slower than that of other pines.

Its well-supplied branches do not assume a pyramidal form; they become straight from their early years, the tree assuming a semi-ovoid form.

When the tree gets older the higher branches spread out more and more, giving it a characteristic form, whence it has derived the name *parasol pine*.

The fruit is formed of large cones highly charged with resin and comestible seeds.

The thick covering of this tree makes it very valuable for rewooding purposes, for it prevents the vegetation of the underwood and maintains the freshness of the soil. It has also been extensively used for plantations carried out by the State, the results obtained being very satisfactory.

Besides, the deep rooting of this variety enables it to resist the action of the wind, thus rendering it very suitable for fixing unstable soils.

For rewooding purposes, seeds may be employed as well as young trees, though as a rule the latter are preferable.

Certain exotic varieties have been attempted to be utilised for rewooding purposes in warm countries, such as the *Eucalyptus globulus*, *Grevillea robusta*, and the *Filao* of Madagascar. As a general rule, these attempts have not been crowned with success.

To sum up, the only varieties which can be relied upon for the rewooding of bare land in warm countries are those having persistent leaves, more especially the Aleppo pine, evergreen oak, and maritime pine.

(2) Temperate Region.

This may be subdivided into two regions, namely—

(1) That with a mild climate—where the vine and English pedunculated oaks are found.

(2) That with temperate climate—where oaks still present themselves, though the forest pine dominates and the beech and fir commence to be seen.

Oaks with caducous leaves form large forest groups essentially com-

posed of the two valuable varieties already cited, namely, ***English*** and *pedunculated oaks.*

The former of these two trees grows well in rough ground, as also upon mountains.

The latter prefers plains with deep, fresh, or damp soils, and is not found upon mountains.

The pedunculated oak is found in the north of France, though very rarely in the south-east. Not being able to subsist on mountains, it presents no interest for rewooding purposes. On the other hand, the English oak is of frequent employment in the Alps for this special point which engages us; it is there met with even at an altitude of about 3300 ft.

If we descend from north to south, it is found that forests of English oak become less and less frequent. In Provence it has completely disappeared, being replaced by groups exploited in the form of coppices.

As a rule, the English oak grows in all situations, though it prefers rather deep soils.

Its thick foliage as a young tree renders it sensible to atmospheric changes. It is therefore necessary to provide it with a slight shelter; this is done by introducing other varieties of rapid growth, of which transitory varieties are made, because they are destined to disappear at the end of a little time.

It is therefore evident from these observations that the English oak is still a valuable species for rewooding purposes.

The **Chestnut-tree** is found in the warm and temperate regions of France. It is very extensive in the centre and south-east of France, though never in proper forest groups.

However, in Alsace and upon certain slopes of the Vosges, it has been endeavoured to constitute from it groups exploited like simple coppices. In the south-eastern mountains this tree, which can live at an altitude of about 3000 ft., generally prefers mellow land, composed by disintegration of volcanic rocks.

This variety of tree is very sensible to frost; strong winds are equally harmful to it. It is especially come across in temperate valleys and upon slightly rapid and non-rocky slopes.

The wood of the chestnut-tree, which is very analogous to that of the oak, does not always possess the same qualities as it; it is especially sensitive to atmospheric variations. Its covering is thick and its growth very rapid.

From the point of view of rewooding, the oak itself is by far the

most preferable, but it can often be utilised for the creation of simple coppices, in view of utilising it in the making of tool handles and especially hoops for casks.

The **Forest Pine**, very common in the plains of the North and East, is also found in the mountains of the Alps of Provence, where it commences to show itself at an altitude of about 3300 ft. In warm positions it even grows at an altitude of about 6000 ft.

This tree forms very beautiful groups, often mixed with other varieties. Preferring sandy and deep soils, it will also prosper even on the most meagre soil, and that which is most exposed to the sun, but it is not found upon argillaceous or too damp soils.

Its tap-root strikes easily in light soils, the lateral roots then being slightly developed; in clayey soils, on the other hand, the same roots take upon the surface of the soil a great extension, even attaining to a length of about 65 ft.

The covering of the pine is very light, which permits of its young shoot easily resisting the heat of the sun.

The timber, which is very good for carpentry, sawing, and building, produces an excellent tar.

After the first four years, the growth of this tree is very rapid, and while still young it gives to the soil an abundant manure.

Being very vigorous and easily living at different altitudes and in medium soils, the forest pine is very advantageous and largely utilised for rewooding purposes. The lightness of its covering and its rapid growth cause it to be equally employed as a transitory variety in the protection of young plantations of oak, fir, and beech.

This variety can be equally employed by seeds or plantations.

It is the only indigenous pine which presents itself in the average region of France; another species of pine—the *laricio pine*—is also very valuable for rewooding purposes.

Two principal varieties of it are known—that from Corsica and that from Austria, or *black pine*.

In Corsica the *laricio pine* replaces the forest pine, and can even grow at an altitude of about 5525 ft.

From a rewooding point of view this variety is not very interesting, because, on the one hand, of its preference for volcanic soils, and, on the other, of its very great sensitiveness to cold, so that in Provence even it cannot flourish at more than an altitude of about 4550 ft.

The **Black Pine** is principally met with in the Styrian Alps at an

average height of about 2275 ft. The climate of these mountainous regions is dry and often very cold.

In France no old group of black pines is met with. However, the naturalisation of this tree is regarded as very useful by our (the French)

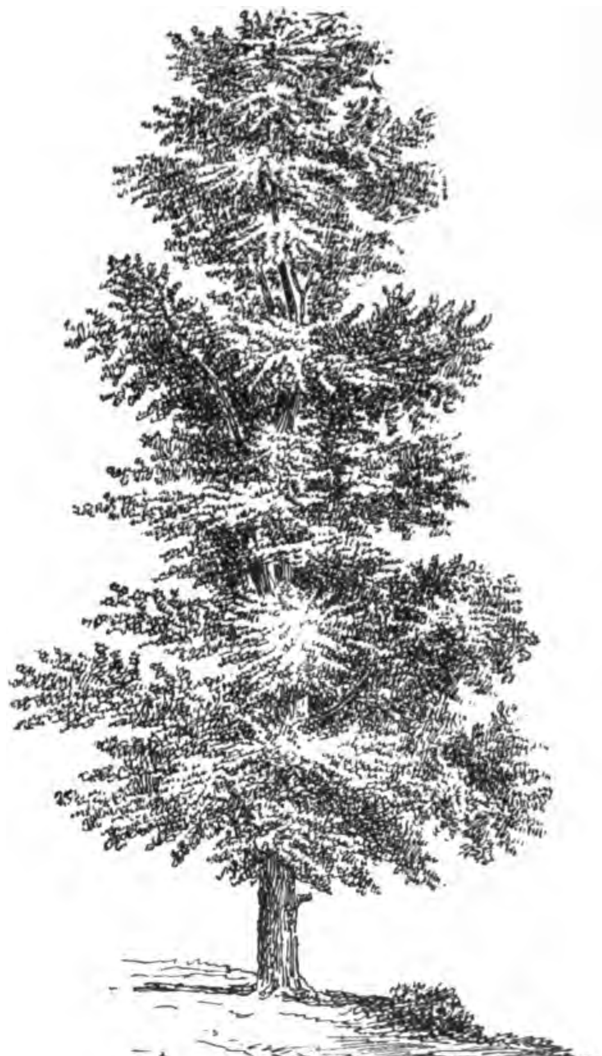

FIG. 115.—Elm.

forest school. In general, calcareous earths are most favourable to it. Its tap-root is early replaced by powerful lateral roots, which give it a very strong hold, permitting it to resist the most violent storms. An abundance of snow does not harm it to such an extent as it does the

forest pine, thanks to the strength of its branches. The top is less subject to attack of pyrales; it also remains very straight.

Its foliage is very thick, and, in spite of that, its young shoots endure the heat of the sun very well.

Its timber is preferred in building to that of the forest pine; it is harder and denser. The fuel which it provides is excellent; it produces an excessively abundant resin.

The whole of the qualities of the black pine make a variety of it which can be recommended for the rewooding of bare ground and calcareous soils. For more than twenty years its employment has been greatly developed, the results produced always being very satisfactory.

If, now, we ascend the scale of altitudes, we come across the *beech* at the same time as the *sylvester pine.* In Provence the beech grows in warm positions to an altitude of from 4000 ft. to about 5525 ft. In cold situations it commences at about 2925 ft., and is never seen beyond 4875 ft.

On the other hand, however, the fir is never found in warm situations, always growing in the North.

These two varieties of trees cannot be employed for rewooding bare land; their young shoots have great difficulty in withstanding atmospheric variations.

Of the two principal varieties of *elms*—the *rural elm* and the *mountainous elm*—only the first has sufficient qualities to render profitable its introduction into the replanting of land with trees. This variety can be utilised even to an altitude of about 4875 ft., provided that the situations are good. Rather fresh calcareous soils are the best; strong and oblique roots then sprout out, giving it a very solid hold. The covering of this tree is thick, and its foliage abundant. Its timber, which is hard and resistant, is very valuable.

If it be desired to utilise this variety for rewooding purposes, it must be done by means of transplantation.

Of the *ashes*, only the *common ash* is recommended for rewooding.

Very common throughout the temperate region, this tree is found upon the mountains at higher altitudes than the elm; it is also seen in the Alps at a height of about 5850 ft.

The covering is slight, and its leaves give a very good forage. It prefers fresh soils, and can still be obtained in beautiful varieties upon dry ground, provided that these latter are mellow and deep.

The qualities of its timber are remarkable; in rewooding it can only be usefully employed by means of transplantation.

As has already been seen, the principal varieties of *maples* are the *sycamore*, *Norway*, *field*, and *Montpellier*.

The first, extensively found in mountains, is often met along with the larch at great altitudes. It therefore belongs as much to the Alpine climate as to the temperate one. It grows rapidly, living sometimes to a very advanced age.

Its covering is thick, and the foliage can be employed as fodder and stable-litter.

With regard to the Norway maple, it is seldom found in the mountains, and its foliage is not so highly prized; it is therefore not very interesting from a rewooding point of view.

The other maples must be employed like the two first by means of plantation; as a rule, they must be employed isolated in the midst of groups having other varieties amongst them.

We will not insist upon the *limes*, *sorbs*, *service-trees*, *wild cherry-trees*, and *birch-trees*, the properties of these different varieties—of less importance from a rewooding point of view—having already been described.

The *robinier*, which comes to us from Northern America, cannot be reproduced. This tree prefers fresh soils; its timber, which is very sinewy, and of rather heavy specific gravity, is largely employed. Its growth is very rapid; it can be utilised for planting, whether in the creating of new shelters or for fixing unstable ground or denuded slopes.

The *alders* and *poplars* offer but little interest from a rewooding point of view; they can, however, be advantageously replaced by certain exotic varieties, such as the poplars from Canada, Virginia, and Ontario.

The *willows* can be used to fix vegetation at the bottom of ravines, equally for fascine and wicker-basket making.

Among the shrubs able to furnish useful co-operation in the work of rewooding, whether in the early fixing of the soil or in the forming of a first shelter to the young plants of the large species, may be cited the *hazel-nut-tree*, *dog-berry-trees*, *hawthorn*, *diospyros*, *Mahaleb cherry-tree*, *juniper*, *Alpine cytisus*, *brier*, *boxwood*, *sea-buckthorn*, and *broom*.

Of all these varieties we shall only retain the *juniper-tree*. We have already said that this shrub belonged to the Coniferous family. It grows in the temperate regions, upon arid soil and principally upon mountain slopes, where it is still met with at very great heights.

The juniper is of wild and deformed aspect, with pendant branches, almost linear leaves, and naked buds. Its average size is scarcely 5 ft. In the south of France it may even reach about 20 ft. high.

The bark of the stem and branches is rough, of a reddish-brown colour, the leaves are lanceolate, and it has a tap-root. The strobile,

which is pulpous and succulent, and which has wrongly been called a *berry*, is formed of modified florets of the female catkin. At first green, then violet, sometimes black, it takes two years before it arrives at complete maturity. It encloses three oblong, osseous seeds, which can be made to germinate advantageously in light and new soil, and without dung. The juniper is also reproduced by means of cuttings and shoots.

The species *Juniperus* comprehends about twenty varieties, having amongst them a deal of resemblance.

In addition to the foregoing, there is the *oxycedar juniper*, which gives by distillation of its wood an empyreumatic oil of tarry odour and of caustic savour, known under the name of *cade oil.*

The *Virginian juniper* is employed in toy-making, and its strong odour preserves the objects manufactured from attacks of insects.

The common usages to which this shrub is put are only of minor importance; it is useful for making hedges and vine-props. Its timber, which is hard and of a red vein, can be employed for lathe-work; its fruit, by fermentation, gives a rather agreeable beverage, and serves in Holland to aromatise alcohol.

This shrub, moreover, propagates abundantly in unwooded places; it can become the most direct agent for rewooding.

Indeed, the falling branches of this shrub form a sort of cradle for the seeds. The earth formed by the arrested detritus is abundant there, porous, and always fresh; the young plants growing under its shelter have nothing to fear from the violence of the wind.

The juniper is an excellent protector. On account of its resistant bark and very dense fibres it can defy all intemperateness of the weather. It holds to the soil by strong tap-roots, which, sparing the superficial mould, strike deep for the nourishment which they need. As is seen, it is one of the most useful species for rewooding purposes.

(3) Cold Region.

In this region we shall again meet groups of beeches and firs, followed, higher up, by the *hooked pine*, *pitch pine*, and *larch.*

The first, the **Hooked Pine,** is found in important groups in the Alps and Pyrenees. It is one of the precious varieties for the rewooding of high and cold mountains, where the pitch pine and larch could not prosper if the conditions of soil and position were unfavourable.

The branches of this tree assume a candelabra form; they are also

far less exposed than those of the forest or black pine to the havoc occasioned by the accumulation of snow.

This variety must therefore be distributed over high slopes.

FIG. 116.—Alder.

In these regions large groups formed by the *pitch pine* and *larch* are equally met with.

But from a rewooding point of view the pitch pine does not present the resources which might have been expected of this variety.

Rather sensitive to atmospheric influences in its early years, it requires from the soil a certain freshness which is only found with

difficulty upon mountains devoid of vegetable shelter. Its employment

FIG. 117.—White Poplar.

is therefore compulsorily limited wherever this protection cannot be procured for it.

The **Larch**, on the other hand, is the fundamental base of all the rewoodings at great altitudes. It is found in France in large groups in the Alps of the Dauphiny and of Savoy. In Switzerland it is found in the mountains of Valais and Grisons.

This variety grows in all kinds of soils, even in that which is at an altitude of about 8125 ft.

When young the larch resists very well the roughest inclemencies without requiring any shelter. Its covering, which is light (owing to its thin, short, and slightly abundant branches), is sufficient to shelter the herbaceous vegetation which is developed around it all the more vigorously as the soil is well manured by the annual falling of the leaves.

For the first three years the growth of young larches is very slow, but after the fourth year they grow rapidly.

This rapidity, added to the capacity of the larch to flourish at great altitudes, make this tree very valuable for rewooding lofty mountains. There should therefore be great interest in its propagation, all the more so as its timber has such excellent qualities.

There are other varieties of the temperate region which can also withstand the rigours of the cold region, the principal of which are: the *ash*, *birch*, *birdcatchers' sorb*, *sycamore*, *maple*, *willows*, *cytise*, *hawthorn*, and *sea-buckthorn*.

If we go still higher towards the summit of the highest mountains, we find as the last representative of forest vegetation the *Cembro Pine*. This variety, which is essentially Alpine, only grows in dry climates. In Switzerland it is only met with in the Upper Engadine, and in France only in one part of the Dauphiny—in the neighbourhood of Briançon.

In Europe it is the only five-leaf pine. Being very robust, it withstands the roughest climate admirably, and can even exist at an altitude of about 9750 ft.

The branches, of candelabra form, close against the trunk, are thus protected from the wind, and easily withstand the weight of snow and frost.

As a rule, it lives in company with rhododendrons and green alder. Its growth is very slow.

Provided the seed-plot is made under favourable conditions of convenient shelter against the clearing away of the soil around the trees, complete success is obtained.

In the Lower Alps, in two rewooding experiments, 20,000 kilogs. of seeds were employed with an abundance of success.

In the following table will be given a statement of the non-resinous

trees which are most frequently employed in the rewooding of mountains, with some numerical information with regard to them:—

Description.	Time of Maturity of the Seeds.	Cost of the Crop of Rough Seed.	Net Cost of the Clean Seed.	Time necessary for Germination.	
				Time of Seed-Plots.	Time of Shooting from the Ground.
		Per 100 Kilos. Francs.	Francs.		
Evergreen oak	September.	14	14	Autumn.	Spring.
Cork-tree	November.	16	16	,,	,,
English oak	October.	12	12	,,	,,
Carob-tree	August.	...	200	Spring.	One month afterwards.
Chestnut-tree	End of October.	15	15	Autumn.	Spring.
Lavender	August.	8	250	,,	Second spring.
Eglantine	October.	10	56	,,	,,
Seeds for Sowing in Nurseries.					
Beech	October.	18	18	Autumn.	Following spring.
Elm	May.	25	25	May.	Three weeks afterwards.
Ash	November.	40	40	Autumn.	Second spring.
Sycamore	October.	35	35	,,	Spring.
Field maple	,,	30	30	,,	,,
Birdcatchers' sorb	,,	45	45	,,	Second spring.
Service-tree	,,	40	40	,,	,,
Lime	,,	50	50	,,	,,
Wild cherry-tree	June.	30	30	July.	Spring.
Birch	July.	40	90	Autumn.	,,
Robinia	November.	15	80	Spring.	Three weeks afterwards.
Alder	September.	10	220	Autumn.	Spring.
Cytisus	October.	40	142	Spring.	One month afterwards.
Briançon plum-tree	,,	10	65	Autumn.	Second spring.
Nut-tree	,,	30	40	,,	Following spring.
Hawthorn	,,	15	24	,,	Second spring.
Dog-berry-tree	,,	15	24	,,	,,
Thorny plum-tree	,,	10	22	,,	,,
Privet	,,	20	46	,,	,,

As a complement of this important information we give on the next page a table of the principal varieties, with the different conditions of soil, climate, and situation in which they must be placed in order to obtain good results.

REPLANTING IN ALGERIA—REPLANTING OF THE CORK-TREE.

In the actual state of the Algerian forests, and with liberty of pasturage, it would have been very difficult to successfully effect artificial restocking; the Law of December 9, 1885, had for its object the arresting of the clearing of land of trees by checking the abusive exploitations and pasturage which lead to it.

According to this Law, every individual, European or native, who wishes to cultivate or remove the bark, in whole or in part, no matter

what the variety, from the forests which belong to him, is compelled to make a declaration of his intention to the Secretary of the Prefecture, for he must not commence his exploitation without authority.

Description.	Soil.	Climate.	Situation.	Growth.
Aleppo pine	Dry, light, calcareous.	Warm.	Indifferent.	Average.
Aspen poplar	Light, damp.	Mild.	North and east.	Rapid.
Austrian pine	Light, dry, calcareous.	,,	Indifferent.	Average.
Beech	Argillo-sandy.	,,	North, north-east	,,
Birch	Fat, sandy.	Cold and mild.	South-east, south-west.	Rapid.
Birdcatchers' sorb	Dry and divided.	Mild.	Indifferent.	Slow.
Chestnut	Substantial, deep, siliceous.	Warm and cold.	East, north-east.	Medium.
Cimbro pine	Fresh, deep, divided.	Cold.	Indifferent.	Very slow.
Common alder	Humid, aquatic.	Indifferent.	North.	Rapid.
Common ash	Water-banks.	Mild or cold.	Shady and fresh.	Average.
Cork-tree	Feldspathic and schistous, light.	Warm.	Southern.	Slow.
Corsican pine	Light, argillaceous.	Mild.	Indifferent.	Average.
Corsier oak	Alluvion, siliceous, and argillo-siliceous.	Warm.	Southern.	Slow.
Domestic sorb	Calcareous, argillaceous.	Mild.	Fresh.	,,
Elms	All excepting too damp argillaceous soil.	,,	North and east.	Average.
English oak	Argillaceous, very deep, and rich.	,,	North-east, west.	Medium.
Fibrous oak	Argillo-siliceous.	,,	North-east, west.	,,
Fir	Fresh and permeable soils.	,,	North and east.	Average.
Fir-cone pine	Light, fresh, deep.	Warm.	South.	Slow.
Flowering ash	Argillaceous, rich.	Mild, warm.	Warm.	Average.
Forest pine	Deep, light.	Mild.	Indifferent.	,,
Hazel-tree	Fresh and rich.	,,	North-east, west.	Rapid.
Holm oak	Calcareous, dry.	Warm.	Warm.	Slow.
Hooked pine	All.	Cold.	South.	,,
Kermes oak	Sandy.	Warm.	Indifferent.	Very slow.
Larch	Divided, cold, deep.	Dry and cold.	,,	Very rapid.
Lime	Fresh, deep, light.	Mild and cold.	North and north-west.	Average.
"Lord" pine	Light, marshy.	Mild.	South.	Rapid.
Marcescent willow	All.	Indifferent.	Indifferent.	,,
Maritime pine	Sandy, deep.	Mild.	,,	Average.
Nettle-tree	Light, fresh, and deep.	,,	Warm.	Slow.
Pedunculated oak	Argillaceous, very deep, and rich.	,,	North-east, west.	Medium.
Pitch pine	Fresh, damp, turfy.	,,	North, east.	Rapid.
Plane maple	Deep, divided, fresh.	,,	Shady and fresh.	Average.
Robinia	Light and fresh.	,,	Warm and sheltered.	Rapid.
Field maple	Deep, divided, fresh.	,,	Shady and fresh.	Average.
Sycamore maple	,,	,,	,,	,,
Tauzine oak	Light and fresh.	Mild and temperate.	Warm.	Slow.
Terminal service-tree	Calcareous, sandy, fresh, and light.	Mild.	West, east, south-east.	,,
Varnish-tree of Japan	Siliceous, light, argillo-sandy.	,,	North and north-west.	Rapid in youth.
White alder	More fresh than damp.	Indifferent.	North.	Rapid.
White service-tree	Calcareous or argillaceous	Mild.	West, east, south-east.	Slow.
White willow	Damp and divided.	,,	Indifferent.	Rapid.
Wild cherry-tree	Dry, deep.	,,	South, west.	Average.
Yoke-elm	Fresh, argillo-siliceous.	Cold and mild.	North and east.	Slow.

The abusive exploitation or pasturage leading, as a consequence, to the destruction of the whole or part of the forest, are comparable in their results with clearing.

The regulations of the Forest Code relative to the clearing away of the forests are applicable to brushwood—

(1) Found upon the top or slope of mountains.

(2) Serving as a protection for streams and water-courses.

(3) Serving as a protection for dunes and shores against the erosions of the sea and encroachment of the sands.

(4) Necessary to the public health.

The following table, extracted from the general programme as to rewooding in Algeria, shows the area of ground to be wooded, and of wooded land to be acquired, along with an estimate as to expense:—

Provinces.	Area of Ground to be Rewooded, and Wooded Lands to be Acquired.			Estimate of the Expense.	
	Of the State.	Of Communes or Tribes.	Of Individuals.	Cost of Acquisition of Land.	Cost of Planting.
			Northern Region.		
	Hectares.	Hectares.		Francs.	Francs.
Algiers	1,027	4,827	12,930	661,500	836,100
Oran	11,017	12,704	17,398	446,300	7,716,600
Constantine	9,855	29,618	...	...	5,921,325
Totals	21,899	47,149	30,328	1,107,800	14,474,025
			Intermediate Region.		
Algiers	...	...	1,000	10,000	550,000
Oran	...	...	...	...	...
Constantine	5,193	1,150	...	15,000	1,008,100
Totals	5,193	1,150	1,000	25,000	1,558,100

Until the Budget resources allow of the carrying out of the general programme for planting with trees land once occupied by forests, the forest service will endeavour to preserve and improve those woods which now exist.

As for the varieties, the employment of the Aleppo pine is preferred, as this will grow in the driest soil. The cork-tree also succeeds very well, but its growth is slow. The wooding of empty spaces with the cork-tree is more easily and economically obtained by means of seed-plots than by plantation, as the latter requires more care and a more intelligent master-hand, necessitating also the previous establishment of nurseries.

The acorn of the cork-tree ripens at the end of October. The most

economical process of gathering it consists in beating the tree during the second half of November, receiving the acorns upon cloths held underneath.

If the ground to be rewooded is covered with underwood, this must be cleared away and the product burnt upon the spot.

If the clearing away takes place in autumn, after having roughly levelled the soil the acorn is sown at random and is slightly buried by dragging along a fagot of thorns. Five hectolitres of acorns per hectare is sufficient for such a seed-plot.

When the ground is not covered with underwood one proceeds by means of tilling, unless the nature of the soil does not permit it; in this case recourse must be had in places to the seed-plots.

Sown in November or December the acorn shoots up in the month of April; if in the spring, it comes up at the end of three weeks.

The young shoot of the cork-tree is robust; it does not, however, fear cover, which is favourable to it.

When it is in the form of a group it grows rather quickly after its fifth year, and commences to form a stem. Its foliage is then abundant and dense. This circumstance, added to the fragility of its branches, causes it to often happen, in mountains where snow falls in winter, that the young plantings of the cork-tree suffer greatly, and have their tops broken off under the weight of the snow and frost clinging to their leaves.

We may conclude what we have to say from a general point of view by stating the certain results which will be obtained by the extinction of torrents, consequent upon the creation of new forests in their receiving basins.

In the first place, the fixing of the soil in the mountains will be an acquired fact; great security for the surrounding hamlets will result from it.

The torrents being then converted into streams, they can be easily embanked and a definite bed fixed: thence disappearance of all dangers for the villages disseminated along water-courses—dangers of inundation rendered much less significant.

The enormous increase of the traffic on rivers and on streams taking the place of torrents will enable the meadow to be developed upon a large scale, and, as a consequence, enhance the richness of the Alpine countries.

The regulation of the flow of rivers in the valleys of mountains and of lower water-courses—a consequence of preceding results—will have for effect the rendering possible of a complete system of

dams, and consequently the conquest of large stretches of land for agricultural purposes.

The protection and safety of a large number of towns and villages—until then threatened by the filling up of the river bed and the diversion of the water-courses—will also result from this.

It is therefore seen what immense advantages of every kind can be obtained by the intelligent planting of those mountains which are at the present day in a large degree denuded of trees.

CHAPTER XV.

EXPLOITATION OF FORESTS.

HAVING previously given some information as to the principles to be followed in the culture, preservation, and stocking of forests, it is now proposed to show what are the best means to be employed to exploit these forests, so as to extract from them the largest possible profit.

The three principal methods of forest exploitation are: the *simple coppice*, that growing under lofty trees (*coppice and forest combined* or *compound copse*), and the *forest*.

SIMPLE COPPICE.

The *coppice* is the mode of exploitation which suits private individuals best, whilst for the State the forest method offers the greatest advantages. The compound copse holds the second rank, and the simple copse the lowest.

The influence of the *régime* of the copses upon the forests manifests itself by two effects equally disastrous: on the one hand, in the degeneration of trees, and on the other, in the loss of the vegetative quality of the soils and their impoverishment.

This baneful influence is due:

(1) To the frequency of the cuttings, which is absolutely contrary to the preservation of certain varieties, such as the beech, which only shoots out again with difficulty from stumps, and though to a lesser degree to that of other valuable varieties, such as the oak and yoke-elm. The latter, indeed, are destined to disappear, in the first place, because there is no complete and veritable regeneration like that which naturally occurs by means of seeds, and, in the second place, because these two varieties encounter, at each exploitation, the more and more dangerous competition of the white woods, the rapid spread of which, owing to their precocious fecundity in light seeds, stifles the varieties of slower growth and later fertility.

(2) To the drying action of the sun and winds, which oppose the formation of the mould, the production of which can only take place under the influence of dampness, heat, and a calm air..

Invasion of the white woods can be combated successfully by clearings and the perpetuation of the valuable varieties assured by sowing or planting the glades when the trees ready for market are cut down; sometimes even by weeding and burning the weeds, which force the oak to shoot forth suckers.

The species most adapted for coppices are: the *Oak*, for the bark; the *Chestnut-tree* and *Birch*, for barrel-hoops and vine-props; and the *Willows*, for the basket trade.

It has already been said that, in order to combat the disappearance of valuable varieties in common copses, it is necessary to have recourse to the practice of weeding and then burning the weeds.

In copses of oak this operation has for effect the augmenting of the quality of the bark, whilst forcing the roots to send out suckers. This process of weeding and burning the weeds permits, moreover, of the cultivation of cereals at each cutting for one or two years, and of thus making up, in the mountainous countries, the deficiency of arable land, due altogether to the poorness of the soil, its uneven form, and to the harshness of the climate.

This mode of exploitation, to which forest craft has given the name of *Sartage*, has been already employed for a long time in Liège and Luxembourg, at different places in Southern Germany, in the Ardennes, in the mountainous part of Franche-Comté, and has since been introduced into France—notably into Auvergne.

But if sartage is useful in certain mountainous countries whose climate is fresh or damp, and whose soil offers a certain compactness, it would present the gravest inconveniences in southern countries upon dry and light bases. In soils of this nature weed-burning would have the effect of multiplying that wood which is of little value (such as hawthorn, bramble, etc.), and likewise of impoverishing the soil.

It is to this practice, applied in Africa by the Arabs under the name of *k'seur* and in Provence under that of *taillades* (cutting), that those enormous fires are due which almost every year devour thousands of acres.

It is therefore seen that the processes and methods of exploitation which, in certain determined conditions, offer the greatest advantages may present very serious consequences if applied in other conditions not favourable to them.

COMPOUND COPPICE.

This method of exploitation consists in leaving upon the spot, at the time of felling, a certain number of chosen reserves amongst the most vigorous trees destined to go through one or several revolutions. It suits essentially the communes, of which about two-thirds of the wooded property is still at the present day in France worked on this plan.

The compound coppice presents the same inconvenience as the ordinary coppice, inasmuch as it favours the invasion of the soil by white woods and tends to impoverish it. There are, moreover, some difficulties as to *choice*, *number*, and *distribution* of the trees to be reserved, which must vary according to the stocking, which must never cover more than one-third of the ground. Here, as in the ordinary coppices, it is consequently necessary to complete by seed-plots or plantations the spaces and glades resulting from the felling of the trees. These replantings are, moreover, partly made by the falling of seeds from the reserved trees.

TIMBER FOREST.

This mode of exploitation is based upon the natural resowing of the soil. If it is worked like a coppice, it will be the young sprigs and the root-suckers which must be planted, in place of that which has been cut; if the forest is worked for its timber, the seeds of the felled trees will sow the vacant spaces.

The mode of exploitation of the timber forest, borrowed from the Germans, is almost exclusively followed—at any rate in Europe.

The natural resowing of the soil is effected by the aid of three successive fellings, called *regeneration fellings*. These are in progressive order, the felling for sowing, having for its object the sowing of the soil, as its denomination indicates; the secondary felling, whose object it is in removing a part of the reserves, to make the young plants participate in the atmospheric influences; and the definitive felling, which removes all the reserves. Vigorous growth of the young plants is afterwards favoured by a series of clearings or glades. But whatever care is carried out in the application of these principles, it is evident that the natural sowing of the soil, left to itself, would often be incomplete, and that to complete it Nature must be assisted.

The most favoured processes of replanting, which resemble the methods of rewooding upon which we have already laid stress, are of two kinds, namely, *natural* and *artificial*.

In forests of lofty trees, the rules of wise economy prescribe the turning to profitable account, as often as possible, of the resources of Nature to assure regeneration. Artificial replantings must be as limited as possible. Often rough tilling of the soil, under the shade of the reserves, permits of the seeds reaching the ground and of germinating under good conditions. The forest plough renders valuable services in this respect.

The usage of the forest plough realises, at slight expense and rapidly, the following advantages: the mellowing, aëration, and making wholesome of the soil to the desired degree of depth; destruction of grass-plots and parasitic plants, which it attacks at the roots, completely raising and turning them over; complete utilisation of the seeds, distributed, naturally or artificially, by covering them with soil.

This implement, moreover, is easily used, not only upon plains, but also on mountains, excepting in rocky or too hilly parts.

In very heavy lands, invaded by the heather or other parasitic plants, weeding, followed by tilling with the forest plough, places the soil in the best conditions for the provision and success of the seed-plots.

GATHERING OF THE FOREST PRODUCTS—FELLING OF THE TREES.

At what age should trees be felled? This question is complicated by several factors which must determine the solution of it.

The age at which it is convenient to cut the wood in order to obtain, in the best conditions, a determined result, is what is called the *exploitabilité* of the wood (that is to say, the most profitable time to fell the timber). The *possibilité* is the quantity of products which a given cultivated forest can produce annually at the age of exploitation.

In the examination of the special conditions of the forest, as a consequence of which the "exploitability" will be fixed, one must apply himself before everything to determine the age limits, beyond which the wood cannot be felled for sale, without the risk of compromising the existence of the forest. If it is a question of a forest of high and lofty trees, felling must not take place before the age when the trees produce an abundant seed of good quality, nor after the time when the groups begin to die off. If it is a question of a coppice, the main point is to obtain from the stocks the most vigorous shoots, and the conditions as to age best suiting this exigency will be inquired into.

These limits are not the same everywhere and for all varieties, so that it is almost always necessary to seek to determine them by special experiments upon the same places.

In good ground, coppices of oak, elm, yoke-elm, ash, and maple can be exploited for twenty-five and thirty-five years. In ground of inferior quality the cultivation of the same varieties may be reduced to twenty years. For varieties of less value, such as the birch, lime, alder, and service-tree, these extreme limits become twenty and twenty-five years in soil of only fair quality.

The exploitation of timber forests can only be commenced when the trees have reached the age of fertility. In general these trees attain this period as soon as they no longer grow in height, and pass it as soon as they commence to decay, and are covered with moss, lichens, and ivy.

Now, is it desired to obtain in a given time the largest stock of wood possible, ignoring all other consideration? Is the largest possible profit wanted in a given time? The solution will not be the same in both cases. But whatever the aspect may be from which the problem is viewed, one of the essential data is the exact knowledge of the law with regard to the growth of trees.

If the growth of trees were entirely aoandoned to Nature, it would only be a question of observing a large number of forests and of studying the law which refers to the annual growth, whether in ligneous matter or in mercenary value. But culture, clearing, etc., have singularly accelerated this growth. A tree forty years old, growing under the influence of favourable circumstances, presents a bulk as large as that of a tree eighty years old, which has grown in the narrow confines of an uncultivated group.

Trees in coppices grow according to a progression which approaches that of the natural varieties. Progress is more rapid in a good soil well planted with shoots, and less so in that of only medium quality. There are also variations according as the species of trees are more or less suited to the soil.

The following progression may be given as an average limit:—

Age in Years.	Value at each Age.	Age in Years.	Value at each Age.	Age in Years.	Value at each Age.
1	1	13	169	25	625
2	4	14	196	26	676
3	9	15	225	27	729
4	16	16	256	28	784
5	25	17	289	29	841
6	36	18	324	30	900
7	49	19	361	40	1600
8	64	20	400	50	2500
9	81	21	441	60	3600
10	100	22	484	70	4900
11	121	23	529	80	6400
12	144	24	576		

It is therefore seen that a coppice forty years old has sixteen times

more value than one ten years old, and four times more than one twenty years old.

It may now be said, from the point of view of the growth of the trees, that—

(1) When the age of a tree in full growth is increased by a quarter, the volume of its wood is almost doubled;

(2) When the age of a tree is doubled, its volume will become eight times more considerable;

(3) When the age of a tree is doubled, its annual growth will be quadrupled;

(4) Consequently, when the age of a tree is doubled, the proportion in which its annual growth enters into the total volume of the tree is diminished by a half.

But before proceeding to felling, it is necessary to write a programme of exploitation, then to make the *estimation* of the woods.

The *plan of exploitation* is a document upon which is inscribed all the information serving to indicate to periods at which fellings may take place.

The *estimation* has for its object the fixing of the wooded products which the forest may periodically furnish, as well as their money value. This estimation is made—

(1) In order to fix the quantity which it is necessary to cultivate;

(2) For the sale upon the spot of products fit for cultivation;

(3) To determine the value of wooded lands offered for sale.

The quality of the trees is also an important factor of the estimation.

Qualities and Defects of Trees.

It is said that a tree is in full growth when its timber is healthy, its bark smooth and of a bright and equal colour, and especially when the shoots of the previous year are long and divided uniformly at the extremity of the branches.

Trees whose bark is dull, cracked, or stained are called "defective" or "damaged."

Roulure is a solution of continuity between the ligneous layers which are not adherent to one another and which lack homogeneity. This malady, often produced by frost, is manifested on the exterior by slits or stains in the bark.

A longitudinal cleft, produced by frost, has been given the name of *gelivure*; it is incurable. The elm is very often attacked by this malady.

If, upon the section of the tree, slits are noticed forming rays like a dial-plate, this indicates that the tree is attacked by *cadranure.* This malady becomes manifest on the exterior by stains on the bark, which is often covered with lichens and fungi; it also forms cracks, by means of which water penetrates into the bark.

In the oak, when the trunk is provided with small branches, from the bottom to the top, it is said that the wood is *red* and the quality of the tree is bad.

When an oak has two sapwoods (*aubier double*) its value is greatly diminished.

The trees of this kind usually grow upon dry and unsheltered soils; they possess one sapwood at the circumference and another in the centre of the stem; the intermediate woody layers are very hard, but the tree is of less value.

When the tree is upon the decline, its wood is lighter in the middle than at the circumference, it loses its tenacity and becomes less elastic. In this case the tree must not be utilised in one single piece, but should be sawed into four, so that the angles of squareness may be formed by the centre.

Shipbuilding timber is especially subject to dry-rot.

As to the quality of the woods relatively to the ground, climate, and situation, it may be said that in watery lands we must distinguish those which are inundated by running waters from those which are only moistened by stagnant waters. These latter soils produce trees whose tissue is fat, loose, spongy, deficient, and tender. On the other hand, watered grounds give birth to trees whose tissue is hard, dense, and elastic. Good and well-drained soils produce the best specimens.

In granitic sand or gravel the trees are of good quality if their roots have been able to penetrate deep into the soil.

The durability of wood varies according to different climates. The wood of forests of the South of France is heavier than that of the forests of the North.

When a tree is isolated, it is, as a rule, hardly fit for being split, but suitable for marine purposes.

North-easterly, eastern, and southern exposures are generally the best, the worst exposure is that of the north-west.

Cubature of Trees.

The cubature of trees is an operation indispensable to the good valuation of a forest.

The operations relative to the fellings assist in determining the cubature of the trees to be felled.

This cubature will be very long and delicate if exactitude is desired to be attained. The operation would be exceedingly difficult in the case of the trees left standing, because their principal dimensions, height and size, can only be obtained in quite an indirect manner.

In practice, one has to be satisfied with rather rough approximations; the heights are estimated by means of the *dendrometer*.

This instrument depends on the properties of tangents. If we consider the angle formed in a vertical plane between the line of sight and the horizontal line from the eye, and also the angle between two lines going, one from the axis of the perpendicular to the zero of the limb, the other to that division of the limb which coincides with the fixed index, we see that the two angles are equal, the limits of one being respectively perpendicular to those of the other. The limb is not graduated equally, for the arcs between every two divisions, starting from the zero, correspond to angles of which the trigonometrical tangents are $\frac{1}{100}$, $\frac{2}{100}$, $\frac{3}{100}$ of the radius, and so on, and these are the numbers which are engraved upon the scale. The zero is placed in such a way that it comes on the vertical passing through the axis of the perpendicular when the guide line is horizontal. The fixed index is placed so as to coincide with the zero when the line of sight is horizontal.

Having given a line from the eye to any point, it is easy to imagine the vertical through that point and also the horizontal line drawn from the eye to meet that vertical. The three lines form a right-angled triangle. The operator observes the angle between the line of sight and the horizontal; in other words, the slope of the hypotenuse or line of sight. Hence, in a general way, the dendrometer gives in hundredths the slope of the line of sight, and hence the height of the vertical, *i.e.* the desired height of the tree, when the instrument is always placed at the same distance, say 30 ft., from the tree.

By the aid of this height and of the circumference or diameter, taken about 3 ft. from the soil, the base of an ideal cylinder is obtained which is reduced to the real volume by means of a factor of conversion obtained by analysis of a tree somewhat similar. For that, the latter is divided into stumps of from 3 ft. to 6 ft., each of which is cubed separately. The whole is added, and the total gives the real volume of the trunk very approximately. This volume, divided by the cylindical volume, furnishes the factor of reduction—that is to say, the number by which

it is necessary to multiply the geometrical volume in order to have the real volume of the stem.

Thus, for the principal varieties, we have the following factors of reduction :—

Height.	Beech.	Oak.	Pitch-Fir.	Pine.
Metres.	Cms.	Cms.	Cms.	Cms.
10	61	62	52	58
25	57	60	50	55
40	54	57	48	53

A still more simple manner of operating consists in employing the cubature process called *the quarter without deduction.* For that the quarter of the average circumference of the tree is taken; this quarter is raised to the square, and the square is then multiplied by the height of the tree. The volume thus obtained is equal to 0·78 of the cylindrical volume.

This process is often adopted because, to obtain the cylindrical volume, the stem is measured covered with its bark; this portion of the stem has no value. A cubature which does not take account of it will not, therefore, present grave inconvenience. Indeed, besides the bark, properly so called, a part of the wood falls which constitutes a loss. Finally, it is admitted that the small error in calculating by cubature of a quarter without reduction can be ignored, and that this cubature gives about the volume of utilisable matter.

Some trees, like the oak, contain a notable proportion of sapwood, which is a zone of the wood completely lacking the necessary qualities, namely, resistance, durability, and solidity.

As a rule, the estimates determine the volumes of the woods to be employed as they should be once in the right place—that is to say, without sapwood; a log of oak, for example, which is not squared—that is to say, which is *en grume* (having the bark on)—has therefore a very different volume from that of the woods which will be extracted from it. To appreciate these differences a special method of cubature is employed called *cubature of fifth or sixth deduction.* With this object, the fifth or sixth of the average circumference is cut off, the quarter of the remainder is taken, this quarter is raised to the square, which, multiplied by the length of the stem, furnishes the volume desired.

Generally this volume of fifth deduction is about equal to a half of the cylindrical volume; that of sixth deduction slightly exceeds it.

All which has just been said applies to the trunk of the tree, but it is also necessary to be able to appreciate the produce of the branches.

The volume of the branches can be estimated at a glance, or one can, as previously, estimate it by analogy with a known yield, given by similar trees felled expressly with this object. The following table is then obtained:—

Varieties.	Proportion between the Volume of Branches and that of Trunks.		
	With few Branches in compact Groups.	Average Quantity of Branches in an ordinary Group.	Abundance of Branches.
	Per cent.	Per cent.	Per cent.
Oak, beech, elm, ash, and maple . .	25 to 53	35 to 45	60 to 100
Pine, pitch, fir, and alder . . .	15 ,, 25	30 ,, 35	58 ,, 80
Birch, willow, poplar, and larch . .	10 ,, 15	20 ,, 30	40 ,, 60

Estimation of the Plantings.

When an account of the value of the trees, taken separately, is obtained, it is afterwards necessary to be able to estimate the *plantings*—that is to say, the important groups of trees. For this purpose one can estimate with the eye either the total volume comprised over the superficial area to be valued, the average volume per acre, or the volume of each tree.

Every tree can also be cubed, either upon one part only or upon the whole of the ground. Comparisons may be made by means of experimental tables.

To estimate at a glance, extensive experience, long practice, and a very correct eye are required. A planting to be judged can only be thoroughly estimated by exact calculations of part of the area. This method is therefore but little employed.

On the other hand, if it is desired to estimate with the eye a known surface, which will serve as a unit of comparison, it can easily be done, and one will be able to rapidly make an inventory of the entire planting.

But the result obtained will be even more exact if the volume of each tree is estimated at a glance. We will not enter into the practical details of this estimation; experience alone can guide one in this respect.

If it is desired to estimate a forest of lofty trees, the possibility of which is fixed by volume, more precise means are employed, or at least *individual cubature* of the trees is always proceeded with.

This method appears longer at first sight, but it is not so, for the

dendrometer is not employed to determine the height of the trees; this is obtained merely by comparison, by making two classes from about 50 to 65 ft., and from 65 to 80 ft.

PRODUCE OF TIMBER FORESTS IN RELATION TO THE AGE OF THE TREES.

Age in Years.	Cubic Metres of Timber found upon Ground of— Good Quality.	Medium Quality.	Bad Quality.
	Oak.		
40	108 to 144	68 to 104	28 to 66
60	212 ,, 280	136 ,, 174	52 ,, 104
80	304 ,, 412	200 ,, 280	64 ,, 180
100	376 ,, 588	280 ,, 392	94 ,, 224
120	468 ,, 748	360 ,, 460	120 ,, 280
140	480 ,, 908	416 ,, 584	136 ,, 348
160	480 ,, 952	416 ,, 668	...
	Beech.		
40	132 to 210	80 to 134	28 to 104
60	212 ,, 318	132 ,, 180	53 ,, 180
80	320 ,, 494	200 ,, 347	67 ,, 290
100	387 ,, 653	280 ,, 402	94 ,, 280
120	547 ,, 800	347 ,, 507	162 ,, 320
140	547 ,, 921	347 ,, 573	...
	Pitch.		
20	83 to 128	43 to 66	13 to 40
40	63 ,, 550	138 ,, 240	47 ,, 109
60	380 ,, 773	266 ,, 393	92 ,, 198
80	614 ,, 1000	370 ,, 574	120 ,, 255
100	775 ,, 1202	464 ,, 735	128 ,, 454
120	921 ,, 1563	548 ,, 962	...
	Forest Pine and Larch.		
20	73 to 132	50 to 86	20 to 53
40	172 ,, 360	122 ,, 208	53 ,, 106
60	292 ,, 574	196 ,, 360	80 ,, 173
80	314 ,, 775	260 ,, 484	120 ,, 212
100	467 ,, 948	305 ,, 580	133 ,, 233
120	377 ,, 1082	347 ,, 593	133 ,, 230
140	377 ,, 1150	347 ,, 601	...
	Fir.		
20	91 to 140	47 to 72	14 to 44
40	69 ,, 616	151 ,, 264	51 ,, 120
60	418 ,, 850	292 ,, 423	101 ,, 280
80	675 ,, 1100	405 ,, 631	132 ,, 365
100	852 ,, 1322	510 ,, 808	140 ,, 499
120	1013 ,, 1719	602 ,, 1058	...

As for the circumference or diameter, they are determined by the forest compass, or decameter. Once all the trees are cubed, a tree for each class is selected to be, as nearly as possible, the best representative of its class; it is felled and its volume is determined as exactly as possible. The figures obtained then give the factors necessary to determine the total volume sought for.

As to the mode of estimation by comparison, this is a modification of the valuation system by judgment. The difference is that in this method the timber is valued according to the results obtained in similar plantations. The figures are ascertained once for all, and tabulated for constant use. (See table on p. 240.)

PRODUCE OF COPSES CONSIDERING AGE AND PERIOD.

Period in Years.	Cubic Metres of Timber found upon Soil of— Good Quality.	Average Quality.	Bad Quality.
Oak.			
10	30 to 54	26 to 30	7 to 20
20	80 ,, 121	53 ,, 70	17 ,, 30
30	92 ,, 174	66 ,, 80	33 ,, 50
40	93 ,, 186	90 ,, 125	40 ,, 66
Yoke-Elm.			
10	27 to 60	23 to 33	17 to 27
20	63 ,, 90	53 ,, 70	33 ,, 53
30	98 ,, 160	80 ,, 100	41 ,, 80
Alder.			
10	67 to 84	40 to 53	7 to 17
20	99 ,, 172	88 ,, 112	10 ,, 66
30	192 ,, 282	129 ,, 209	16 ,, 60
40	264 ,, 387	160 ,, 224	16 ,, 99
Beech.			
10	26 to 53	23 to 30	7 to 19
20	56 ,, 113	50 ,, 66	17 ,, 48
30	92 ,, 180	80 ,, 104	33 ,, 60
40	99 ,, 240	94 ,, 134	40 ,, 80
Hazel, Willow, and Aspen.			
5	23 to 26	16 to 20	2 to 3
10	41 ,, 53	33 ,, 36	16 ,, 20
15	46 ,, 71	45 ,, 46	23 ,, 26
20	76 ,, 80	53 ,, 54	23 ,, 26

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The extreme figures indicate the more or less compact state of the plantation; the lower ones are applied to the thinned and defective groups, whilst the higher figures must be taken when a normal planting is to be estimated.

Similar tables can be set up for the produce of copses; the foregoing is given as an example of the principal varieties met with in this case.

The observations made with regard to the first table also apply to the later.

Cuttings and Felling.

The name *cutting* is given to that portion of the forest to be felled, whether this felling refers to the whole or a part of the trees.

In order to fix a cutting or to establish its proper situation, the extent of the forest to be felled has to be determined upon.

The cuttings are *primary* when they are found in groups which can be felled; they are called *improvement* cuttings when they are limited to partial fellings destined to favour the growth of plantations.

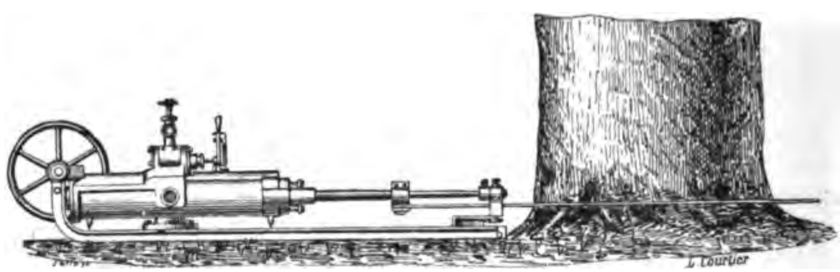

Fig. 118.

The cuttings of a forest must conform to certain rules, to which the name of rules of position is given, and which are summed up as follows:—

First, the cuttings must succeed each other in the order of cultivation, and their form must be regular.

Secondly, the cuttings must be arranged so that the felled timber can be easily transported.

Thirdly, the cuttings must be fixed in such a manner that, in following them, one always proceeds from the north or east to the south or west.

In the mountains felling must always be commenced on the low ground, ending with that which is more elevated.

The felling must be proceeded with cautiously, so as to avoid damage with the falling of the tree. If it is separated at its root, it must be

cut as near as possible to the soil, to avoid the hole caused by the falling of the tree.

If the tree is cut close to the ground the shock of the fall is lessened.

Very sharp instruments must therefore be used, to avoid the breaking of the shoot and bark.

If the sprigs are less than 4 in. in diameter, the bill-hook is employed; if above those dimensions recourse must be had to the axe.

Until recently only the axe and hand saw (called "cross-cut saw") were used to fell trees; to-day, however, a great economy of time and hand labour is saved by the employment of the right-bladed saw-mill and by the direct action of steam (Fig. 118).

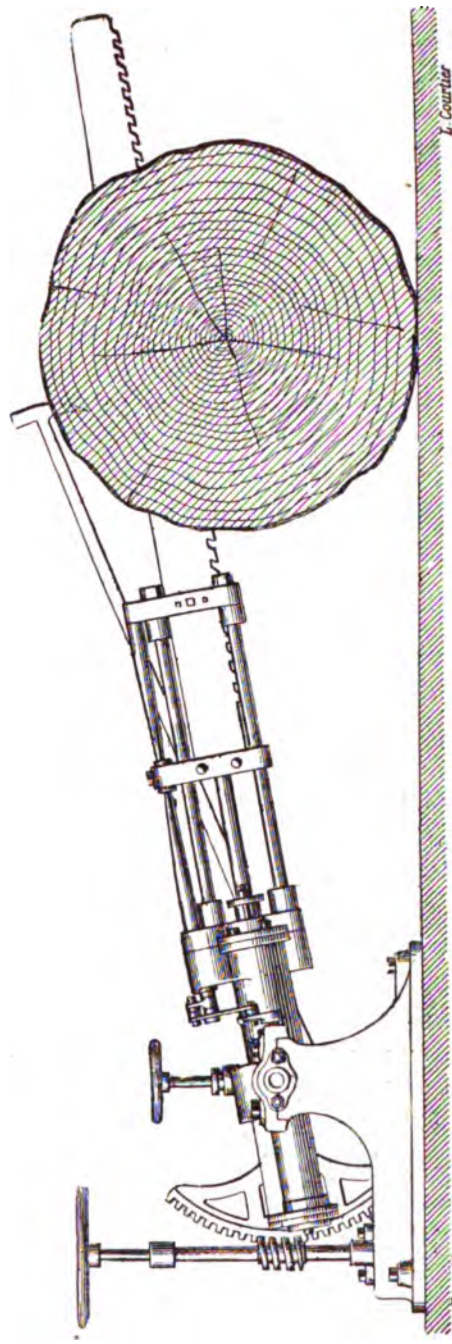

Fig. 119.

This sawing appliance is very light; it can be easily transported to the forest, suspended from the axle of a small vehicle. A strong catch-screw, upon a bar with points buried into the tree, amply suffices to fix it for putting it into action. The speed of its work is very great, for an oak with a diameter of about 3 ft. can be felled in a few minutes. Including the time taken to transport it from one tree to another, this sawing machine can easily, in a day of ten hours, fell forty trees of this dimension.

To employ this apparatus properly, it is necessary to give to the

blade the true tenter teeth, but well separated, so that the sawdust can be easily passed through its teeth, and, moreover, it is necessary, as far as possible, only to proceed with fellings when the sap is down—that is, at the beginning of winter. As lubricant, soapy water is preferable to oil, which tends to form, along with the sawdust, a mastic which is injurious to the working.

The right blade can assume all positions; it can also be employed for the cutting of trees upon the steepest slopes; besides, the position of the tool can be so transformed as to render possible the cutting through, and at all lengths, of the trees upon the ground, whether in the forest or the woodyard. The sawing appliance then receives the name of "slice-cutting saw" (Fig. 119).

It is also seen that this saw permits of cutting the tree on a level with the ground; it therefore saves in a tree of 3 ft. 3 in. diameter at least 800 cubic decimetres of the best part of the wood—of that part which would be chopped into pieces if the tree were felled with the axe.

This saw consists, as will be seen upon reference to the illustration, of a steam cylinder of small diameter attached to a light frame of forged iron, upon which it is arranged so as to pivot upon a centre; the pivoting movement is obtained by means of a hand-wheel, which causes a thread-screw to revolve, working into a quarter of the circle at the rear of the cylinder.

The blade is fixed directly at the end of the trunk, which is made to go straight by means of guides, and the teeth of this blade are so lodged that they only cut during the course of entry. The saw therefore works by traction. This very simple arrangement permits of the employment of saws of from about 8 ft. to 9 ft. without tension apparatus, because its own cutting is sufficient to guide the saw in a straight line through the tree, and, as the teeth do not offer any resistance to the outgoing course, all possibility of flexion of the blade is avoided.

Any movable steam-engine can be employed to provide this implement with steam. But when the saw-mills are not to be set agoing upon the felling ground for cutting up, a small portable copper kettle may suffice, which provides the machine, which is at high pressure, with the necessary steam, by means of a strong and flexible pipe; and as this latter may be of considerable length, the kettle does not require shifting until the saw has cut all the trees in the line determined by the length of the steam pipe.

TIMBER TRAFFIC—SAW-MILLS.

HISTORICAL.

The tree, once felled, must be cut up according to the usages for which it is intended. For that purpose, appliances more or less bulky and very variable, are first employed, and to which the name of "saws" has been given. The first employed, and still to-day largely distributed, are actuated by water, and bear the name of "saws" or "hydraulic saw-mills."

A thirteenth-century manuscript would appear to carry back the invention of hydraulic saw-mills beyond that period, and to make it contemporary with the Roman occupation in Gaul. According to other writings, a mill for sawing wood must have been erected in the fourth century upon the river Rœur, in Germany, and there were similar machines in 1420, at the time of the discovery of Madeira, for sawing the excellent timber of this island; some must also have existed towards this epoch at Breslau and Erfurt. Their usage, however, was not widely patronised in England before the year 1555—the period mentioned by the Bishop of Ely, Ambassador of Queen Mary, at Rome, as being the first time he had seen one of them in that town.

This date is somewhat analogous with that when Jacques Besson, of Lyons, describes one of them as all the more remarkable because it possessed several blades contained in a vertical chase, which caused, under guiding grooves, an articulated parallelogrammatic system to move, reminding one of that of the ancient arrow drawbridges, excepting that here the prolongation of the superior plyer was put into action by a vertical crank, with winch fixed at the end of the horizontal beam. This system also calls to mind the last purview of the steam-engines of Watt, the reproduction of which has been attempted in our time.

There is reason to believe, however, that the majority of saw-mills of this period, and, *a fortiori*, those of former epochs, resemble to a certain degree the more ancient and ruder saw-mills with which we are acquainted, notably those seen but recently, and which can still to-day be observed in the mountains of the Vosges, the Black Forest, Mount Dore, for cutting into joists and planks large trees of pines or firs by means of sawing frames with vertical grooves raised towards the bottom, like pestles, by a beam with cogs which directly cause a small hydraulic wheel with buckets to actuate, executing even thirty evolutions per minute.

In these rough machines, entirely constructed of timber whose perpendicular saw falls heavily upon a heap of sawdust, the piece is mounted

upon a carriage with supporting rollers and lateral guides. This carriage is sometimes inclined to the horizon, rising against the edge of the blades so as to afterwards facilitate the return of the empty piece; but it is more generally established on the level, and provided, under at least one of the shafts, with long wooden racks, pushed forward or toward the saw, by means of small spindle trundles established upon an inferior horizontal and transverse beam, carrying besides, on the exterior, the large wheel with vertical iron ring, called *minutes*, because of its 360 teeth.

This wheel is a true ratchet, furnished with catches against the recoil; a double-splice fork, fixed on the end of a long wooden handle, makes it revolve from one, two, or three notches. This fork, inclined to the horizon, receives at the other end, by a bolted fork, the alternative movement of advance and retreat, by means of a small lever or driver with graduated holes, mounted on a beam horizontally oscillating. This latter beam, placed sometimes towards the bottom, sometimes towards the top, and parallel to the frame of the saw, is itself put into action by a long articulated arm with pulley piece with the cross-bar of the top or bottom of this frame towards which the carriage and the piece to be cut are constantly pushed. The return empty operates by raising the catches and acting with foot and hand against the pegs, whose wooden felly of the "minute" wheel is armed laterally.

The ingenious mechanism of the double splice and of its wheel with battering-ram, the author of which has remained unknown, has been religiously preserved in the different systems of saw-mills and more or less analogous machines. It has very probably been the common source whence Lagarouste himself obtained his lever with double oscillating catch, and, in reality, it constitutes the type of the most ancient automatic saw-mills.

Ramelli, who wrote shortly after Jacques Besson, described with great care a wooden saw-mill quite different and approaching those universally put into use in the eighteenth century. Bélidor, towards 1736, constructed one of them for the arsenal of La Fère.

The system of the double splice and carriage is at once observed in this implement, here horizontal, and carried over a row of parallel cylindrical rollers, where the counter-slope is replaced by recoil suspension weights, which relieves the double splice during the advance of the waggon. It is besides there seen that the frame, instead of being raised vertically by lifts with successive jerks, receives the continuous coming and going of a short inferior crank, mounted upon the iron winch of the beam, bent horizontal by a hydraulic wheel, with great speed and direct action.

One circumstance which it is especially necessary to observe is that the ratchet system, with double splice driver, of the saw-mills described in the *Diverse ed artificiose machine del capitano Augustino Ramelli*, conforming in every respect with that already given, is arranged so as to push in front the carriage and piece of timber during the raising of the frame, precisely as shown by Bélidor, but not during the descent, as is done at the present time.

The vertical frame of this saw is furnished, between its extreme horizontal traverses, with a movable cross-bar upon grooves, and carrying the superior hook of the blade of the saw, banded by means of two strong vertical screws, descending from the higher headpiece and provided with locking nuts.

The *Raisons des forces mouvantes* of Salomon de Caus (1615–1634) comes in the order of dates after the treatise of Ramelli. In this book the illustrious inventor describes a sawing machine with three blades commonly employed in Switzerland for cutting firs into planks.

The machine is furnished, like the preceding, with a "minute" wheel to make the piece advance. Following the indications of the author, the carriage must be accompanied with recoiling counterpoise, with cables and returnable pulleys to facilitate the return empty of this piece, whilst the frame itself was led by a long crank or wooden vertical length and a strong iron winch.

This system, which usually accompanies a strong wooden fly-wheel in the ancient German saw-mills, greatly resembles that which has been followed later by Bélidor.

In this antique kind of sawing machine, as in that of the Dutch windmills, which comprises three vertical frames suspended to lengths or reversed cranks, which actuates an iron shaft with triple winches, the service of the pieces at the entry or going out of the works is operated by means of thick cord passing over the returning pulleys, and ending on the one hand at the small waggon or sleigh which carries these pieces, and on the other at a rolling windlass, which actuates the impellant wheel described in Bélidor's system.

In 1815, upon the return of general peace, our (*i.e.* the French) large artillery and marine arsenals were on the point of becoming as advanced as those of England, with respect to the mechanic work of timber, and especially sawing.

It was only towards 1821 that sawing machines were established at Stenay, near Verdun, with alternative movement, for the cutting of large wheel fellies by means of a single blade, mounted over the vertical frame of an ordinary sawing machine.

The vertical beam of the carriage was placed outside the grooved posts of the large sawing frame, whilst the platform itself, provided with a pair of bellows to drive the sawdust away, was joined, by a cord rolling up on the exterior, to the mechanism of a very rough equipage with wheels, trundle, and double splice.

It was also at about the same time that a very large windmill was erected in the Rochefort maritime arsenal, with exterior gallery, in accordance with the Dutch system, destined to make a saw-mill with several blades go either isolated or simultaneously.

Towards 1820 Hacks introduced into France the employment of the large circular saws of Brunel, with some improvements, consisting in their being lighter, having greater speed, less thickness, and cutting, as a consequence, a larger number of united veneering leaves in a given thickness.

The same builder gave, at the same period, to commerce sawing machines with alternate movements, a certain number of which were intended for sawing the trees horizontally on the spot, or to truncate them after felling.

It is, however, since the time (1825) when M. Cochot established and propagated in France his ingenious and light system of sawing machines with horizontal alternate movement that our cabinetmakers managed to free themselves completely of the onerous tax which they had until then paid the foreigner, and to which, thanks to repeated and appreciable reductions in the motive power necessary and the loss of timber, they competed all the more formidably because this reduction was accompanied by a remarkable perfection of finish.

It is also dating from this period that Parisian cabinetmaking in valuable, indigenous or exotic wood excelled that of all other European countries, not only for taste, but also for its relative cheapness.

In 1826 the Society of Encouragement for National Industry opened a competition for the perfection of wood-sawing machines; the programme of this competition insisted particularly upon the necessity of articulating the frame of large sawing machines with alternative action with their impellent equipage, in such a manner as to imitate the work of the sawers and to suppress in some manner all friction, by thus procuring for the tool the balancing observed in the arm sawing, in itself so advantageous, in facilitating the disgorgement of the sawdust.

This competition did not produce any appreciable results. Towards 1830 M. de Manneville placed himself in the first rank for the construction of alternative vertical sawing machines, as also for those for truncating and with circular blades.

These large vertical alternative sawing machines, constructed entirely of timber, offered an intelligent combination of the old system of Dutch sawing appliances with winches, long superior or descending cranks, double splice and ratchet wheels, with some of the elements borrowed from other utensils, such as extreme horizontal clutches for fixing and suspending the strong uncleft pieces, vertical pegs and eye-flaps with grooves slightly sloping so as to assure a slightly oblique direction of the frame of the saws.

In addition, this builder made himself eminent by a then new combination, since imitated, by means of which he succeeded in cutting up, in the natural direction of the fibres, the bent timber previously dressed and squared upon its exterior surface. For this the piece was freely placed upon a row of horizontal supporting rollers, without either seat or back, and compelled it to go towards the equipage of the saw-blades, conveniently reduced in size, by means of two vertical cylinders turning upon themselves, arranged in front and as near these blades as possible.

One of these cylinders, in channelled brass, served to laterally carry away the piece by its rotation; the other, which was larger and of wood, served to press the opposite vertical surface of the piece by a system of counterpoise, suspended by returnable pulley chains. This ingenious combination suppressed the ordinary waggon of sawing machines, and left at the two ends of the plank every freedom of gliding transversely over the roller supports, and permitted of the sawing equipage following the natural direction of the fibres or lateral and vertical surface of the wood.

This historical sketch being concluded, a description of the different kinds of sawing appliances actually employed will be given.

Sawing Machines for Rough Timber.

The trees having been felled, either by the axe or by the aid of the right-bladed saw and by the direct action of steam, cross sawing, which is most frequently done on the spot, is afterwards proceeded with.

Fig. 120 gives a modification of sawing machine with direct action represented at Figs. 118 and 119. Instead of being with direct action, it works with leather strap. One or the other system is employed, according to circumstances. The different machines about to be described are utilised to square, conveniently and rapidly, large uncleft wood for use in carpentry, marine, and commerce.

All industries using timber utilise these sawing machines, which give the first form to the felled trees. Cultivators of forests, builders

of waggons or ships, carpenters, etc., can thus, thanks to these machines, substitute for the handwork of the long sawer the rapid and precise work of the vertical sawing machines.

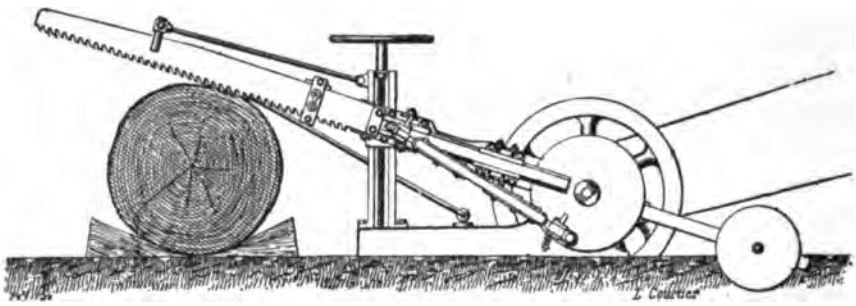

Fig. 120.

The alternative vertical sawing machines with several blades for straight sawing (Figs. 121, 122, 123, 124) receive as many blades as desired. These blades together work the piece of timber placed on the waggon. Two blades permit of squaring; one alone in the centre splits the large trunks in two, the quality in the middle of which it is necessary to know, and two, three, five, ten, and even fifteen blades may divide the tree at one single time, and in a straight line in as many kerfs as there are blades placed.

But generally in practice one proceeds differently in dividing the work.

It suffices to place six or eight blades in the frame in order to obtain large wooden planks, which are afterwards squared by circular sawing, then engaged in a cylindrical sawing machine to be divided by a single cut in as many planks as desired. The costly employment of a large number of blades is thus avoided; it is difficult to place them regularly, and they take a long time to sharpen. Moreover, there is a saving in motive power.

The dividing apparatus seen at Fig. 125 can be applied to the model of saw shown in Fig. 121. In this case the tree can be split into two parts or divided into leaves or panels.

Fig. 124 represents a double sawing machine, by means of which one can, by the aid of two frames of different dimensions, either cut up at the same time uncleft timber of about 28 in. and another of 20 in., or cut into planks the squared wood of the large frame. The purchasing of a cylindrical sawing machine is thus avoided.

If it is desired to saw the uncleft wood according to any curvature, or the natural bending of the tree, or a line traced upon the piece, the many-bladed vertical saw is obtained (Fig. 126). This sawing machine

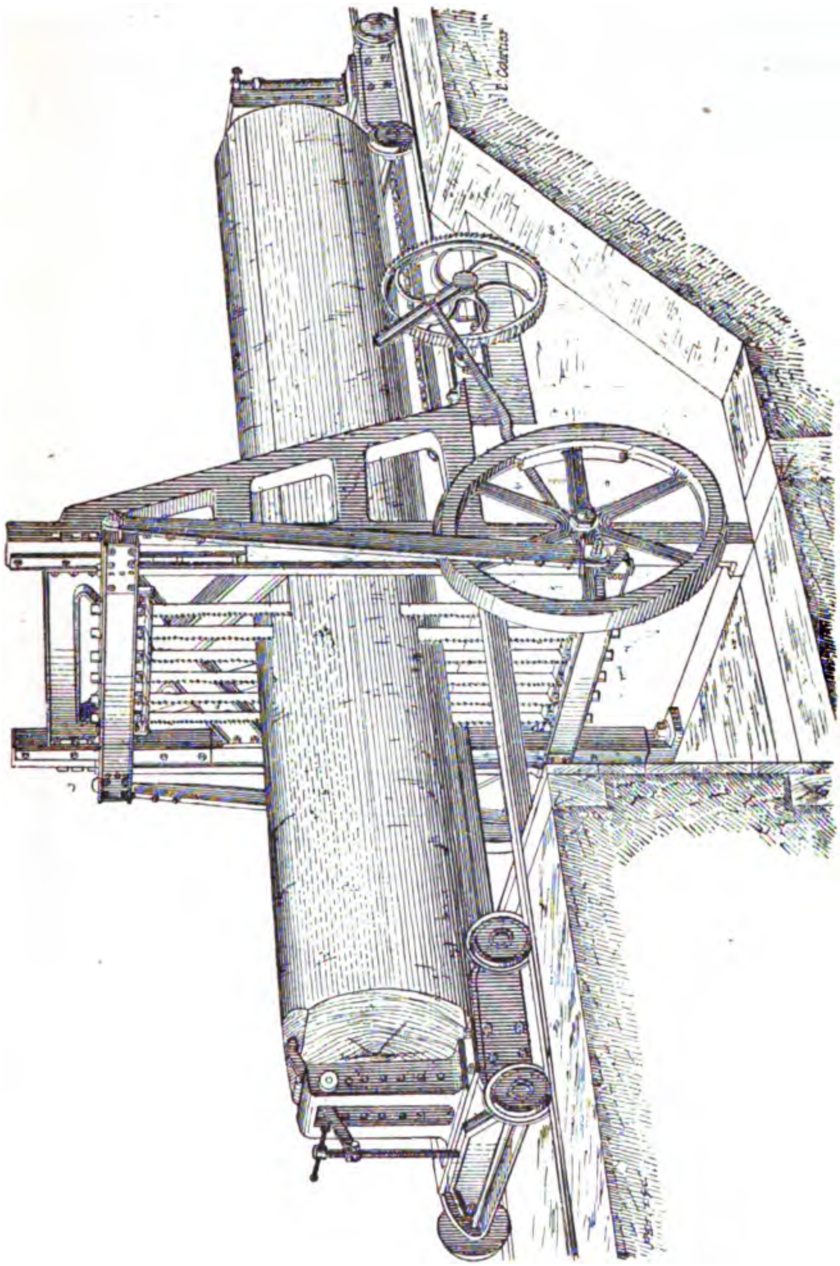

Fig. 121.

is furnished with special appliances and arrangements, by means of which the workman, placed near the blades, can easily direct the timber following the line given.

Fig. 125 represents a vertical sawing machine with a blade upon the side with the dividing apparatus. This machine only makes one single kerf at a time, but this is of great precision, and allows of the varying of the thickness of the leaf, panel, or wooden scale after each kerf. The

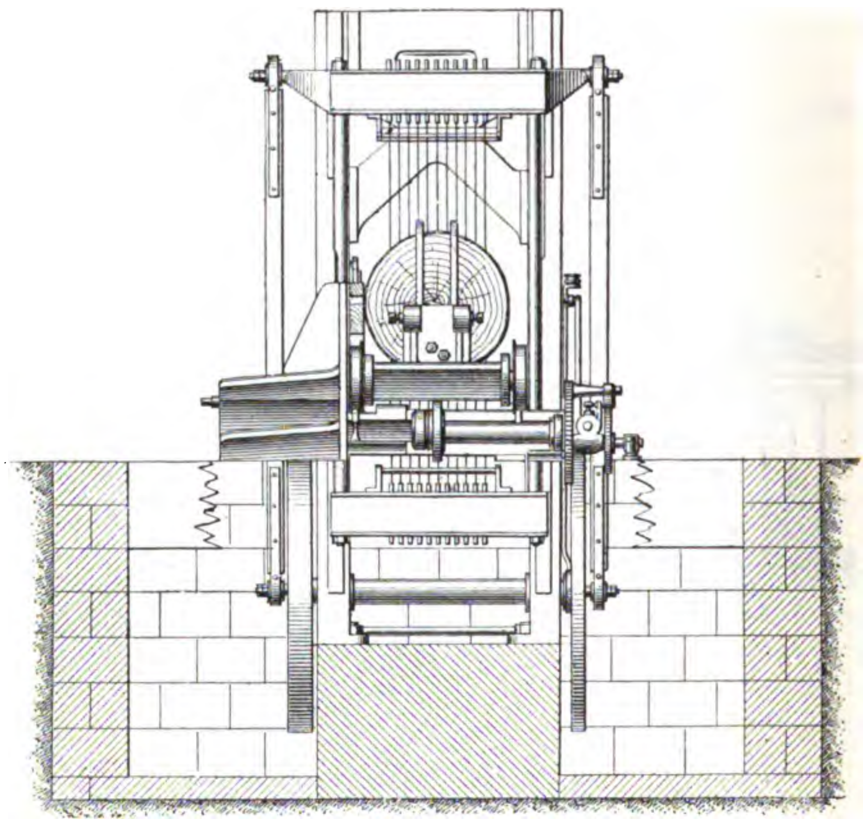

FIG. 122.

very stiff blade can relatively be thin, and takes little wood for the thickness of the kerf.

The blade is divided throughout its length into several equal parts, each comprising four teeth with double inclination—that is to say, each part has its teeth inclined contrary from the preceding and following part. The saw thus arranged offers the great advantage of continuous action like the circular saws without the inconveniences of the latter—in other words, the blade works as well whilst ascending as descending, thus enabling double production.

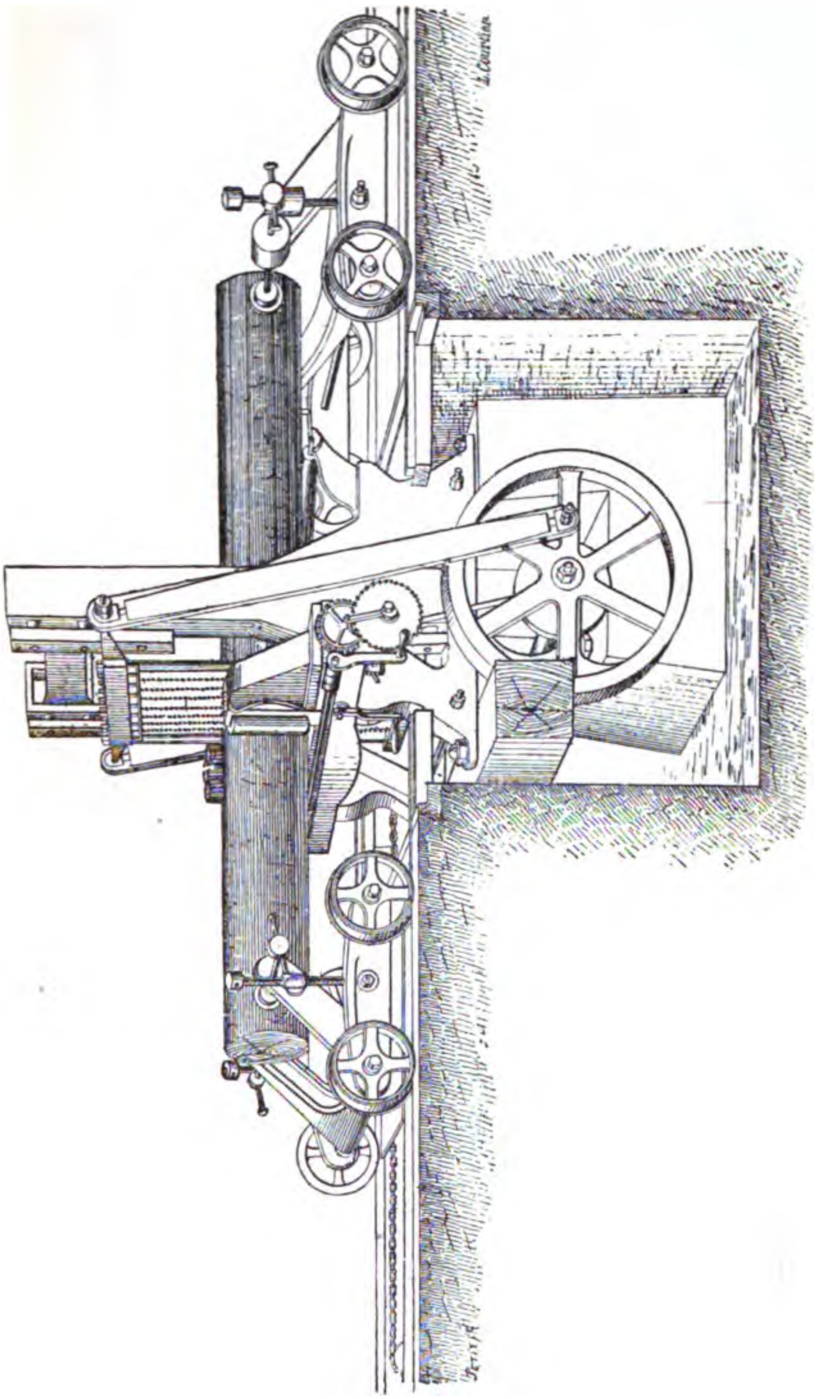

FIG. 123.

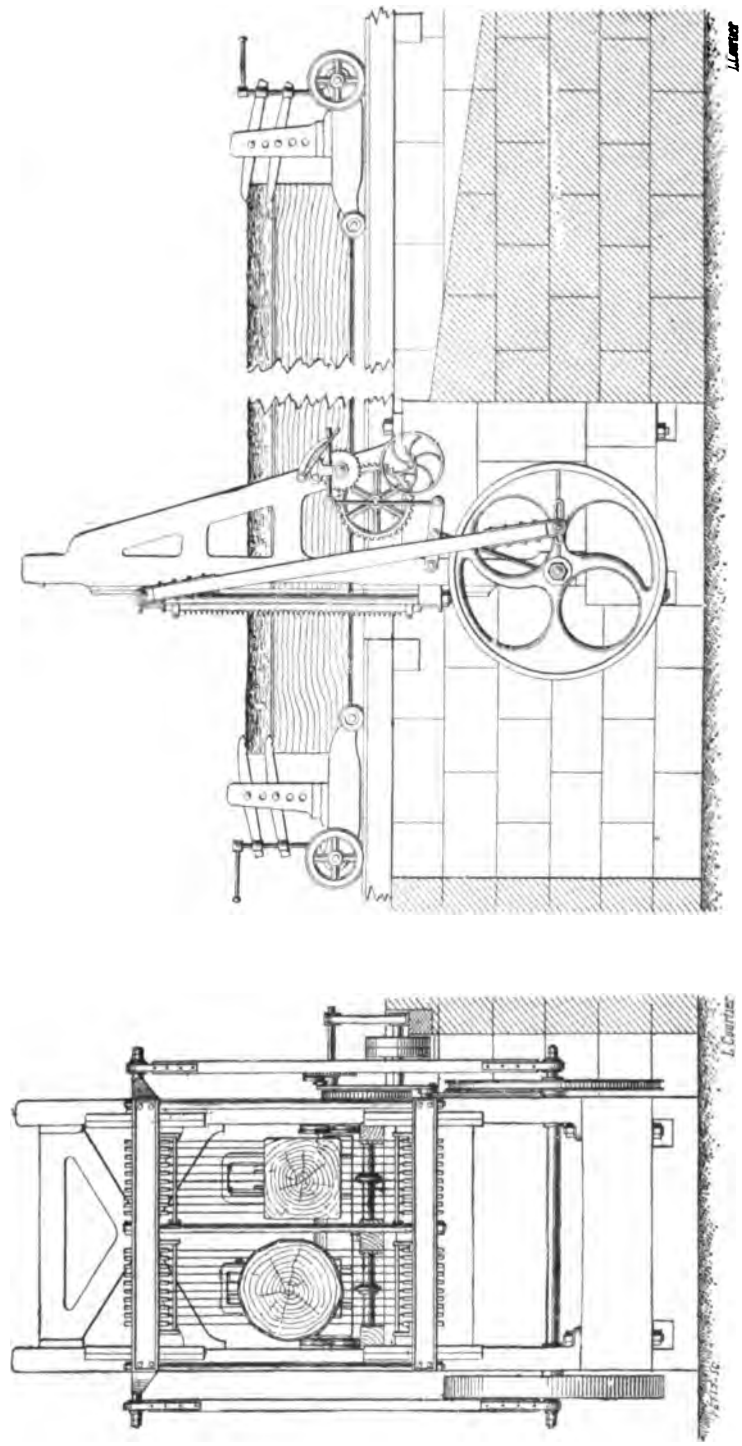

Fig. 124.

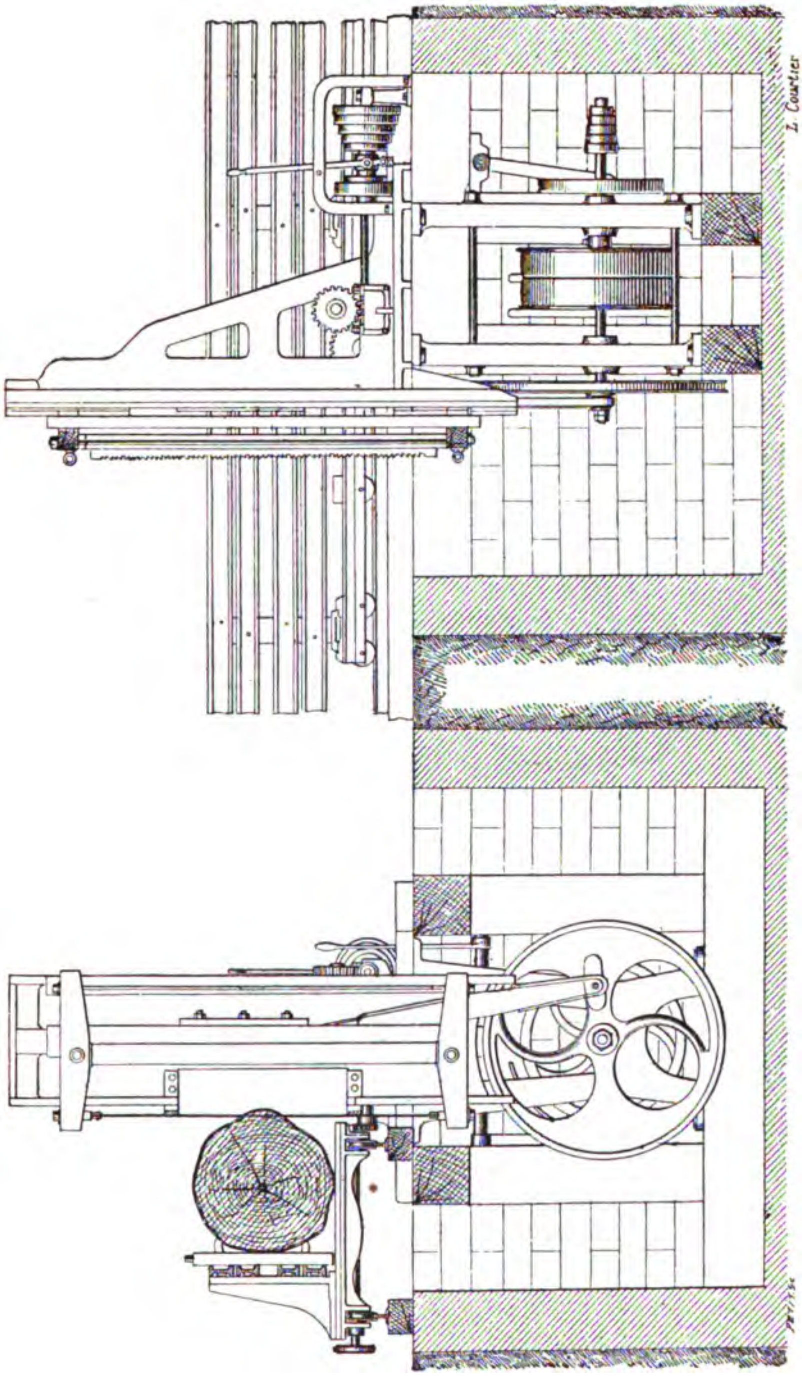

Fig. 125.

The contrivance carrying the timber does not advance alternately by means of a ratch; this advance is brought about in a continuous

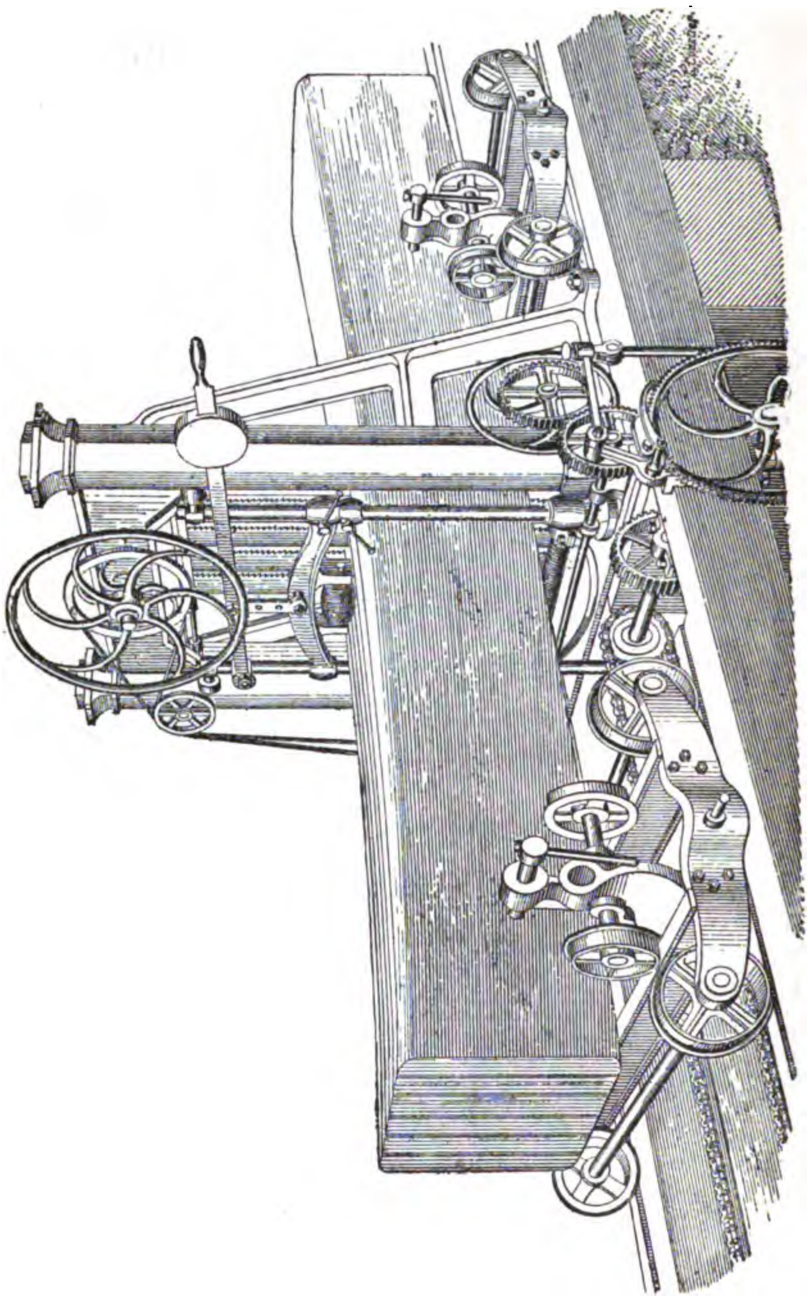

Fig. 126.

manner by the effect of cone-like pulleys with double friction engagement.

It is generally as well to prefer, as often as can be, the installation

with a moderately deep pit (Fig. 125) not exceeding $5\frac{1}{2}$ ft. The maintenance is easier, the work is better, and the sawing more regular. The saw can attain very great speed, and even make two hundred and fifty strokes a minute.

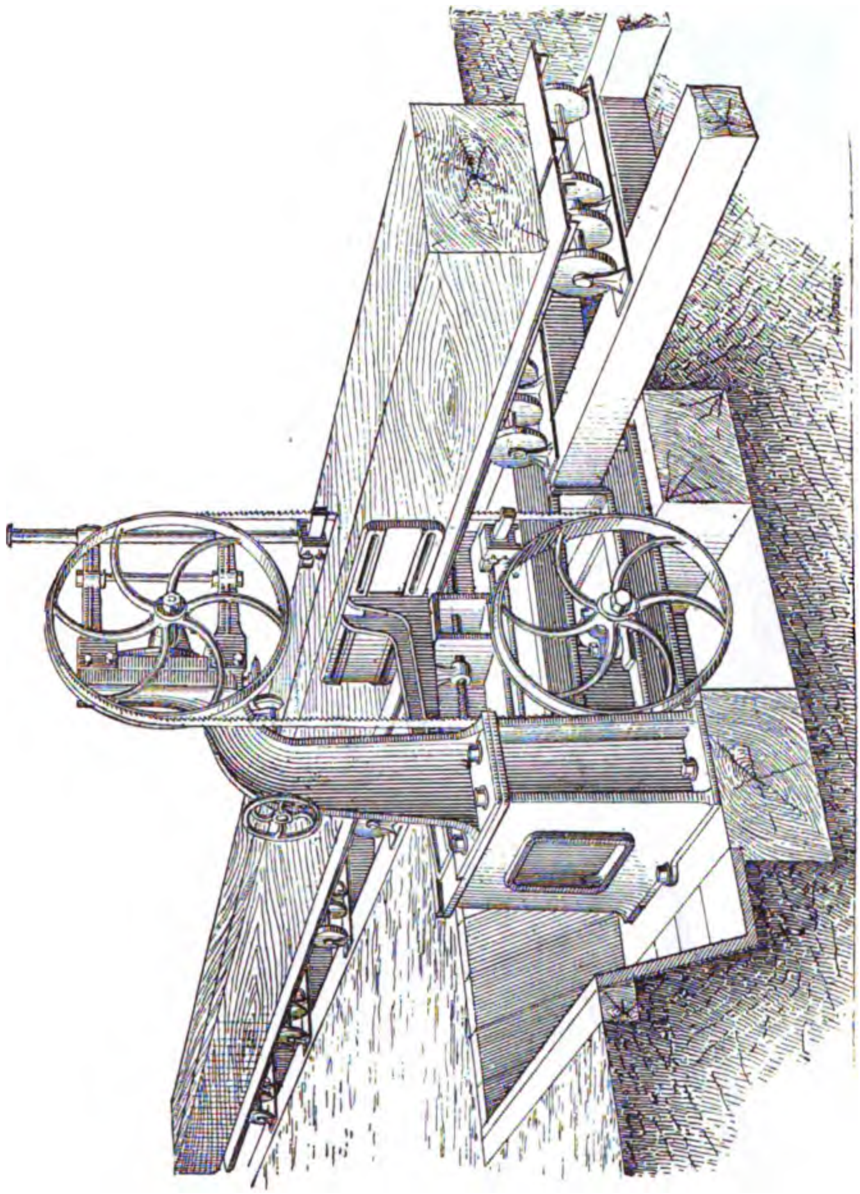

FIG. 127.

The sawing machine with an endless band saw is perfect for all works of cutting in profile and for cutting curves; it can also be applied for the straight sawing of rough timber (Figs. 127 and 128).

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Thanks to the dividing or double arrangement, it can serve the same purposes as the alternative vertical sawing machine.

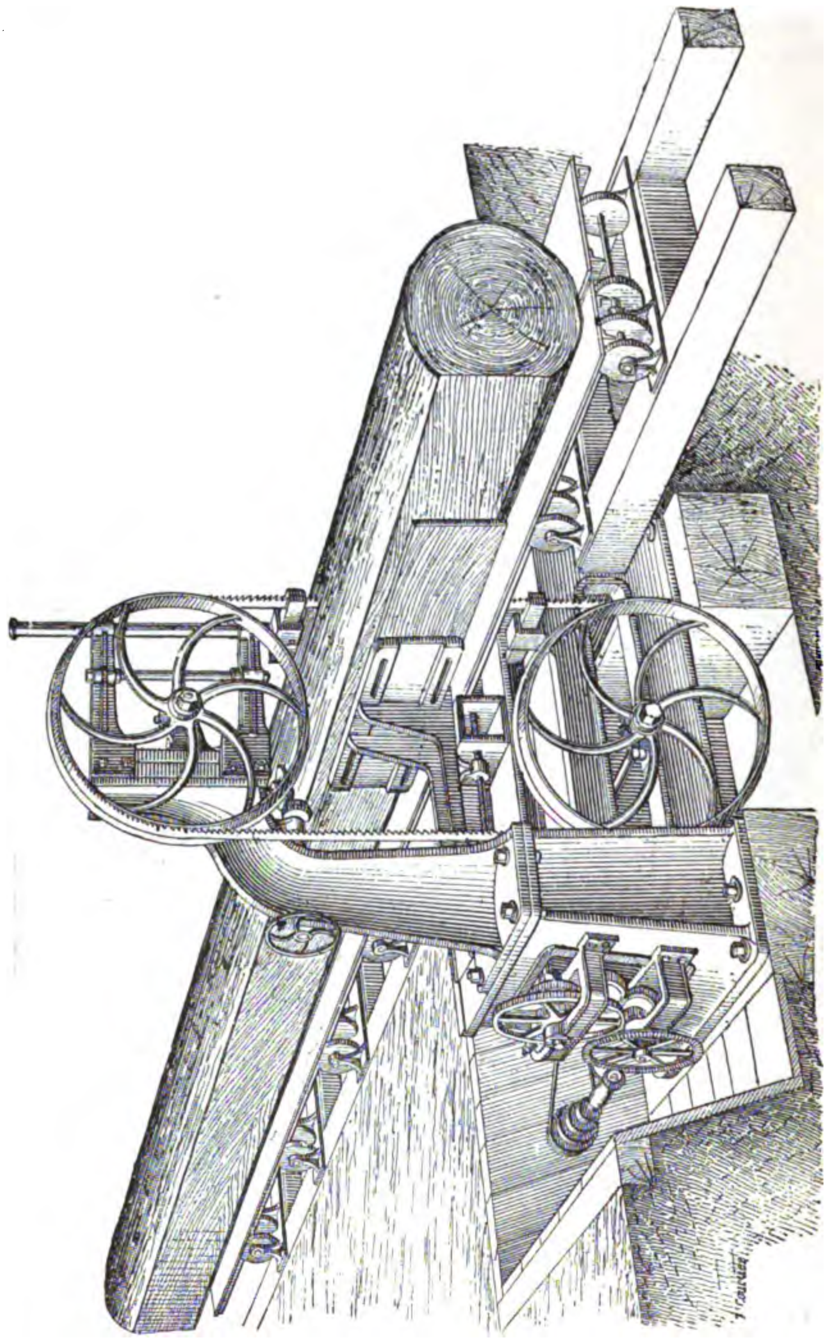


FIG. 128.

This latter, however, is superior to the first both for sawing and simplicity of maintenance.

Although the blade may be on the side (Fig. 125) the timber can be worked even to a thickness of 10 in., and the management of timber with the bark left on is very simple. It is commenced by clamping the timber upon the carriage for the first cut, it is then successively quartered and complete squaring is arrived at; or, placing the first surface dressed on the side of the carriage, the division of the piece of timber into planks, leaves, or panels is very easily obtained and with great precision.

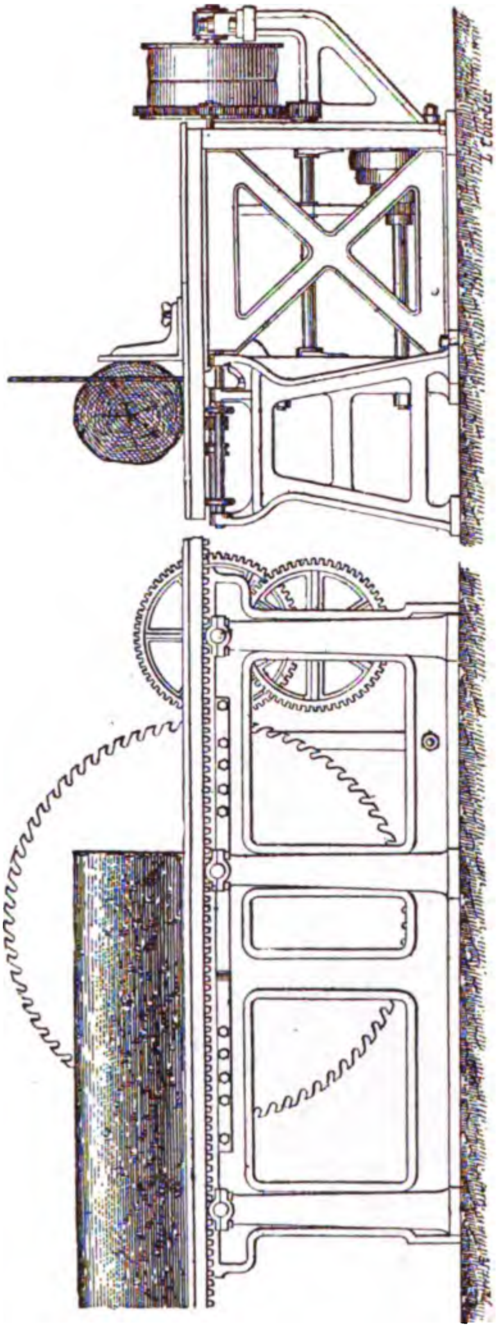


Fig. 129.

The alternative vertical sawing machine therefore appears to us easier than that with a band saw, applied to straight sawing of rough timber.

An ordinary workman can do excellent work with the former, but to use the latter to the best advantage, he must be a clever and expert worker. This is owing to the excessive care needed in the sharpening of the band saw, which is about 26 to 33 ft. long. This being so, it cannot be bent much for fear of heating the bearings; it therefore results that if the track of the saw is not very regular, and

if the timber is rather difficult, the band does not saw in a straight line through the timber and the guides are helpless to keep it in

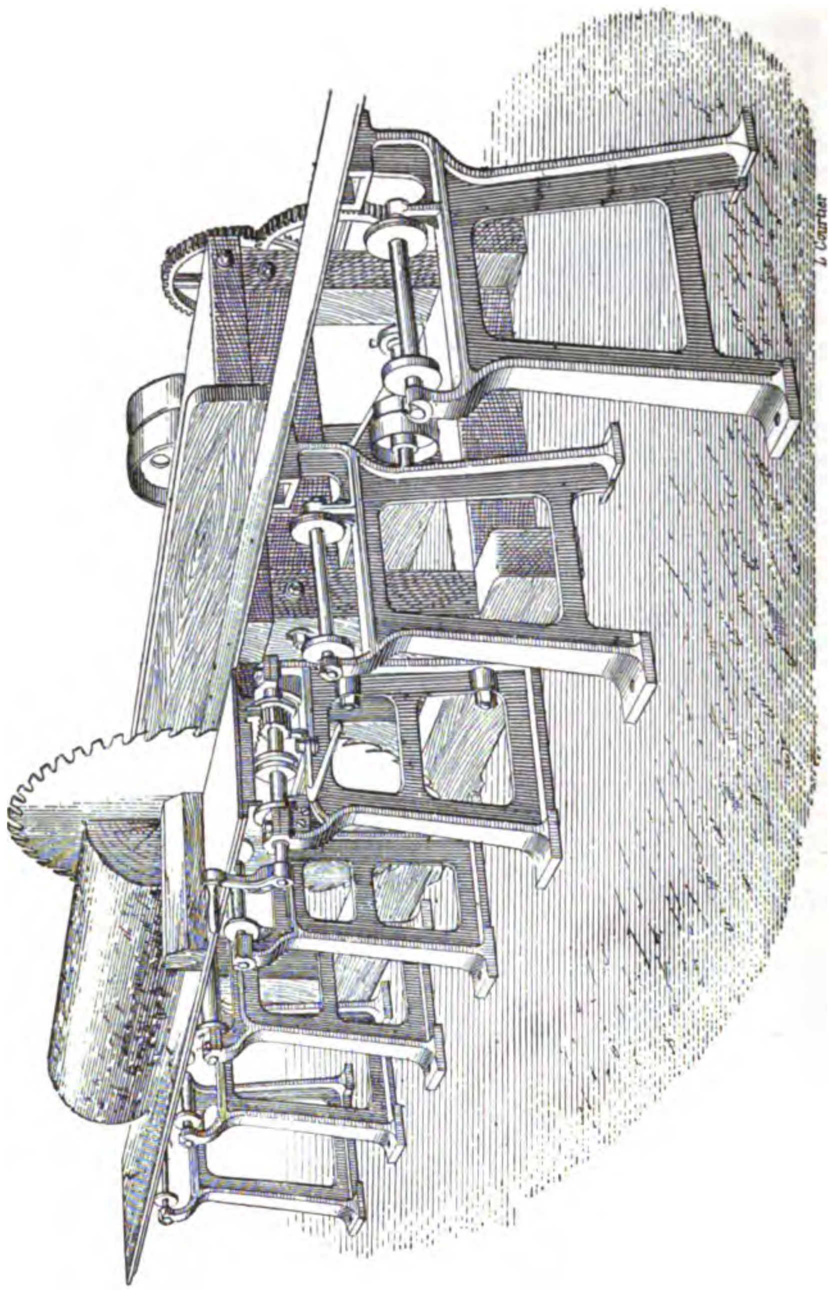


Fig. 130.

register. This inconvenience does not exist in the case of small timber guided by hand.

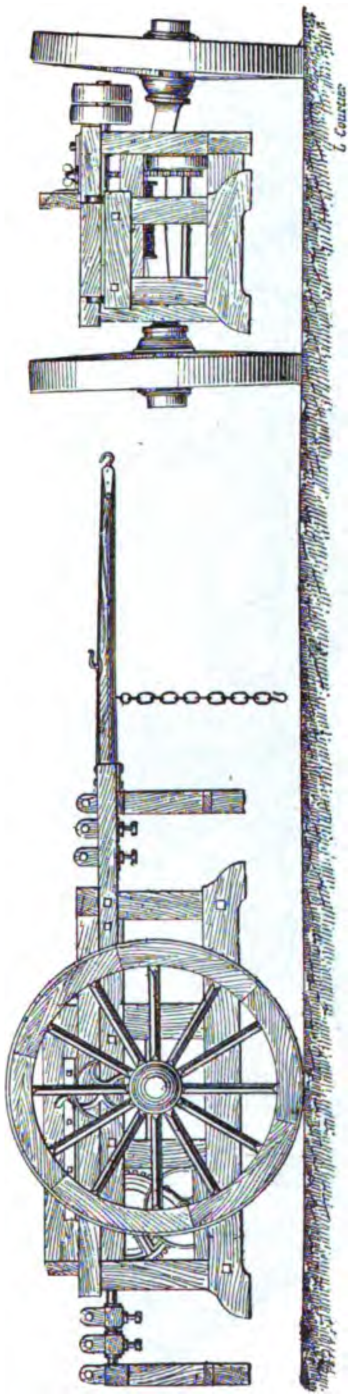


FIG. 131.

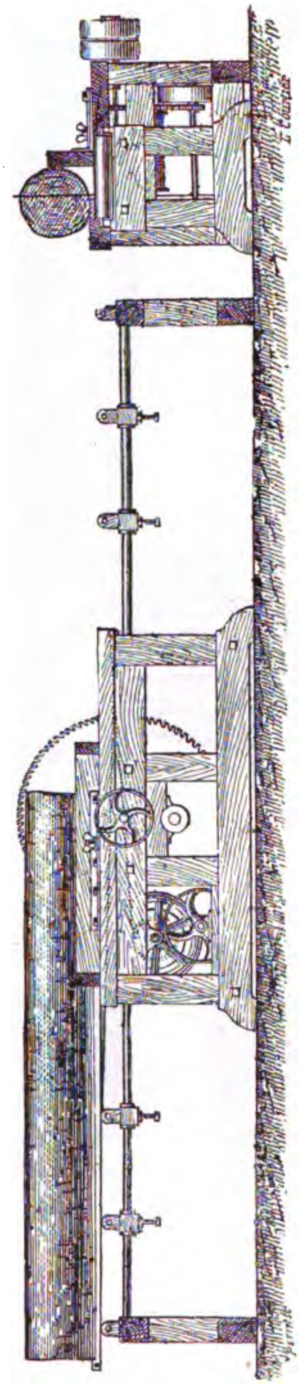


FIG. 132.

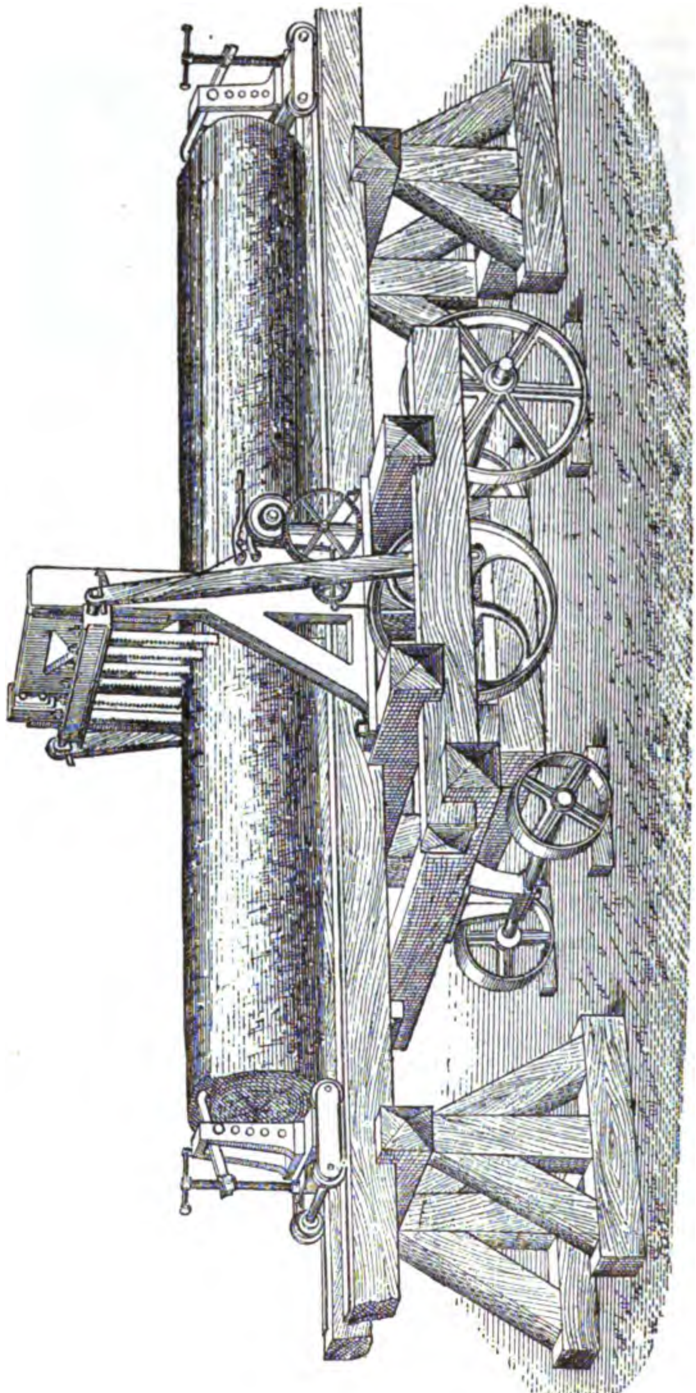


FIG. 133.

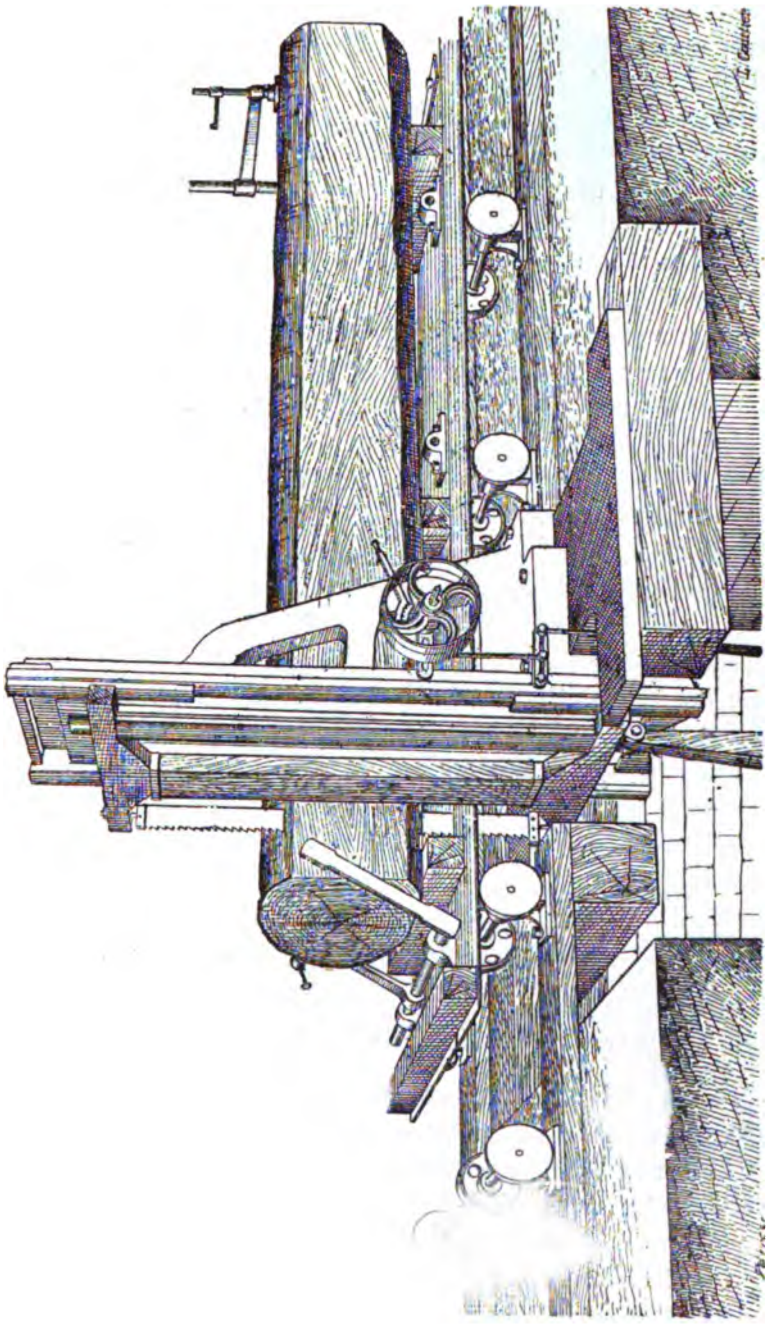


FIG. 133A.

However, there are cases where, for cutting up rough timber, sawing machines with circular blades, provided with carriages supporting the timber, are preferable.

These appliances can be mounted upon iron or wooden foundations (Figs. 129, 130, 131, 132).

All these machines are stable and easily transported, and can be conveniently set up in forests.

The width of the cut of the saw produced by the circular blades of large diameter limits the employment of these blades to the division of round timber into two or three parts. Each of these parts is afterwards subdivided, by means of blades of smaller diameter and less thickness, into planks, battens, laths, etc.

In temporary exploitations use is often made of vertical saws mounted on wheels to facilitate transport (Fig. 133), but the shaking up produced by the alternative movement of the parts necessitate the provision of a solid foundation, and this deprives these implements of most of their advantages.

It appears to be more certain to employ types of half-fixed sawing machines, requiring neither a deep pit nor a foundation, and which can easily be installed upon the ground, but which are transported by means of independent waggons.

Such are the sawing machines represented at Figs. 121, 122, and 123, for the groundwork of which a frame or wooden construction, solidly bolted, is sufficient, which can be taken to pieces and transported like the different pieces composing the saw.

The circular saw-mill lends itself very well to the exigencies of instantaneous transport.

The motive power necessary for working these different saw-mills generally varies from 4 to 6 horse-power for ordinary timber.

Sawing Machines for Squared Timber.

When the round tree has undergone different operations of squaring, it should afterwards be subdivided or rapidly cut into two parts.

For this new work alternate vertical sawing machines with one or several blades are employed, which give one or several cuts to the squared wood of slight dimensions or the planks which come from sawing machines uncleft, beams of fir, and the timber of commerce (Figs. 134, 135, and 136).

In these saw-mills the wood is guided and led forward in a continuous manner by vertical rollers; they succeed each other without

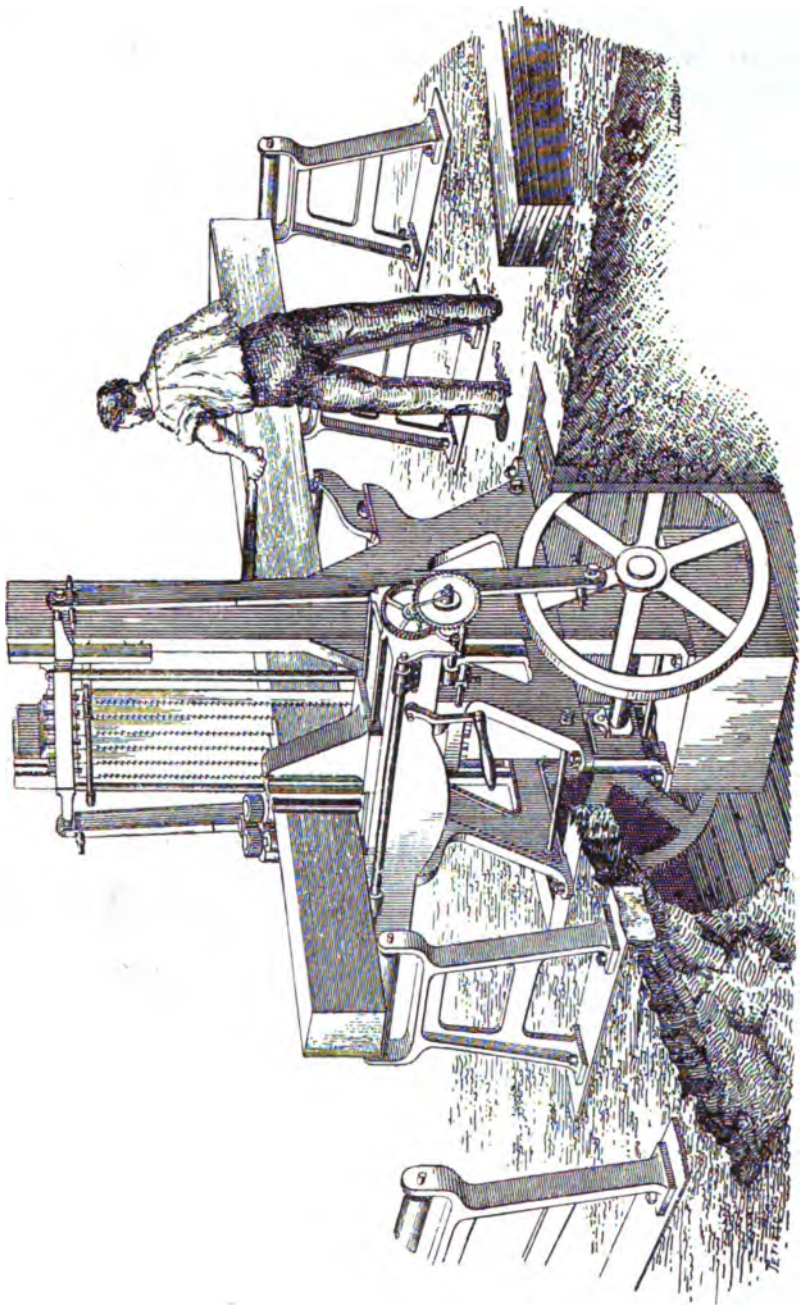


Fig. 134.

interruption, one pushing the other, and the very lengthy pieces are carried away the same as the smaller pieces.

When the piece of timber is too large, the rollers are not sufficient to run it; in this case recourse must be had to the addition of an automatic appliance.

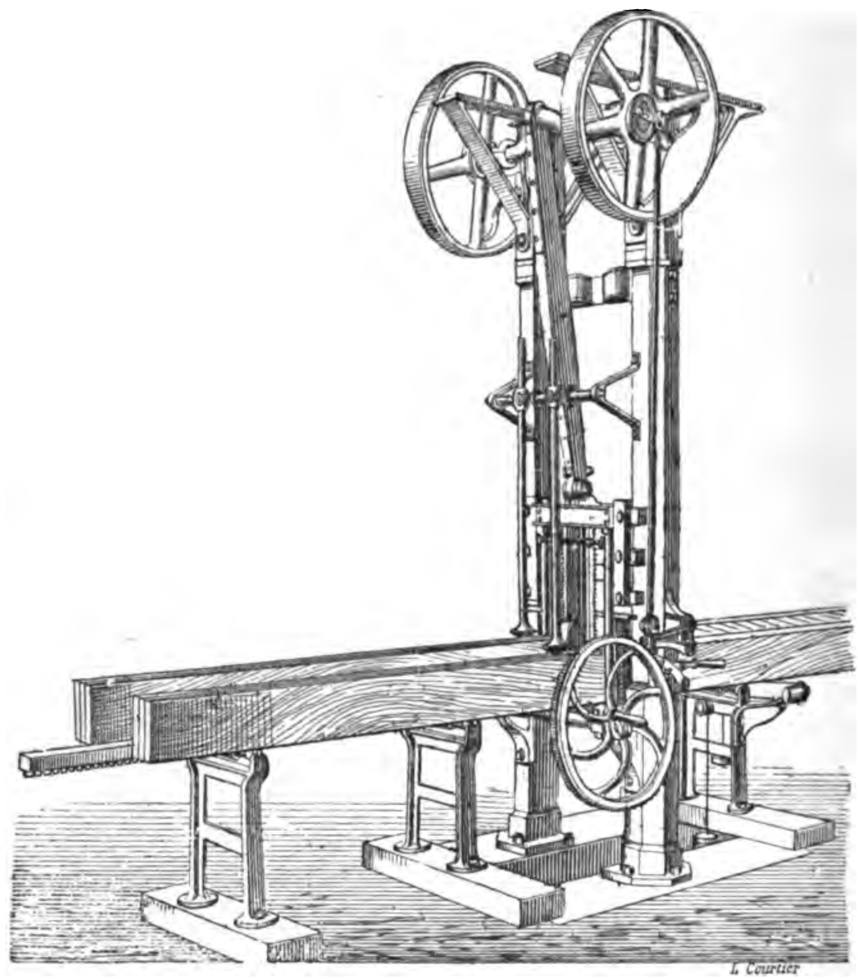


FIG. 135.

A special arrangement permits of cutting two joists at once by employing as many as twenty blades at the same time, ten on each side. The number of blades corresponding to that of cuts desired to be obtained, one can arrive at six, eight, or ten cuts in a joist. This model, provided with cylinders and spring-backed carriage, is employed especially for cutting the timber of the North. The frame, carrying sixteen or even twenty blades, is of absolute rigidity.

These different models of saw-mills can be installed over a pit, or if the water and nature of the ground do not permit of this, without a deep pit, but with side frames.

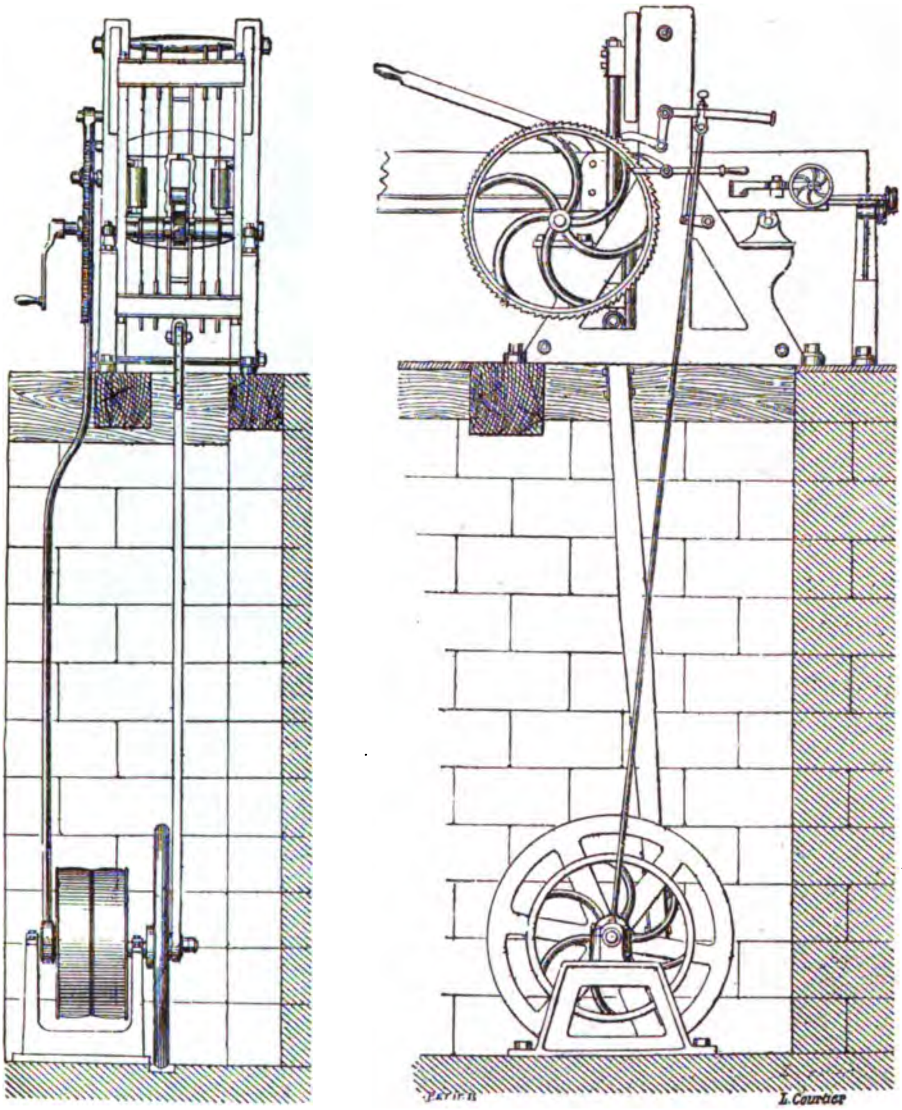


Fig. 136.

The number of strokes of the saw per minute may be about 150; 3 to 4 horse-power will suffice in normal conditions.

A machine is finally used to cut the squared wood in two; it is very precise in its action, and by its aid valuable timber can be subdivided into panels of any width.

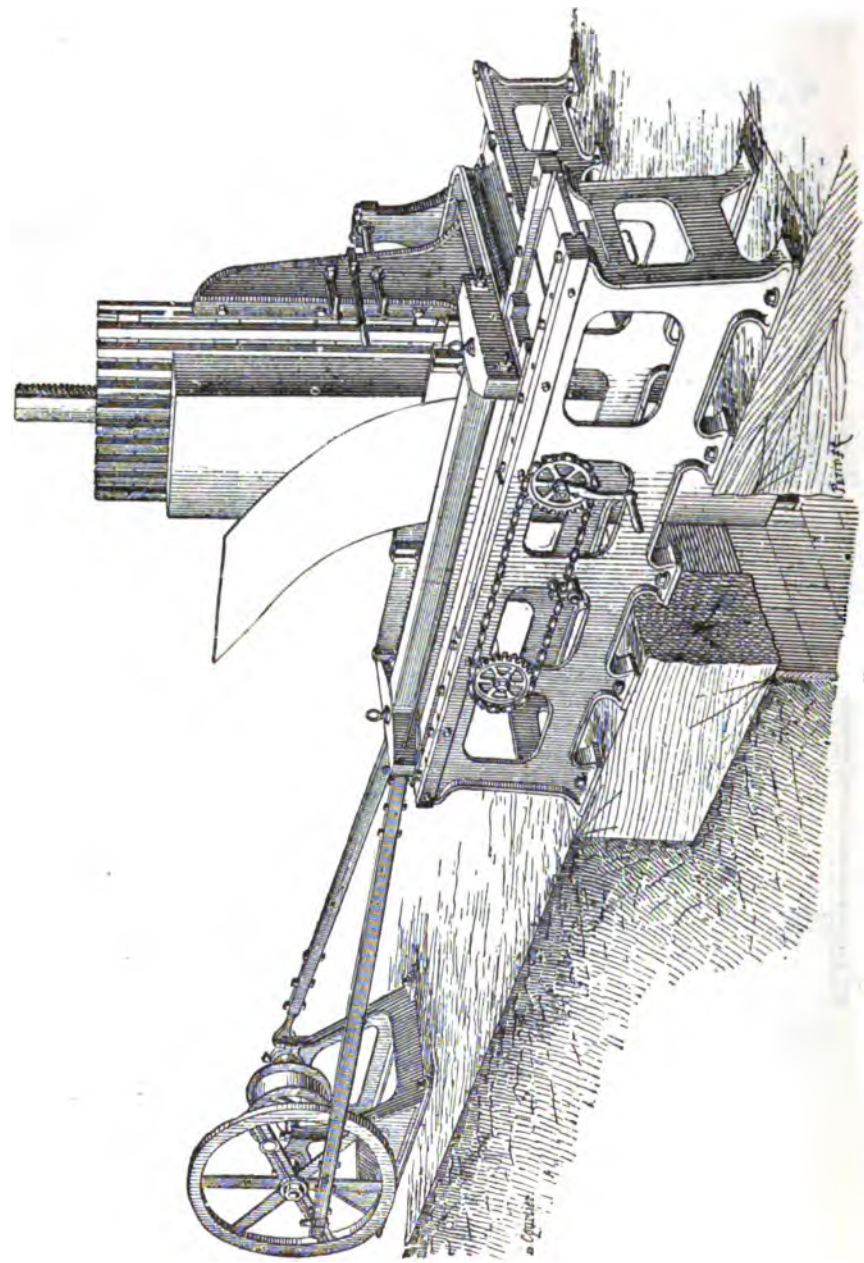


FIG. 137.

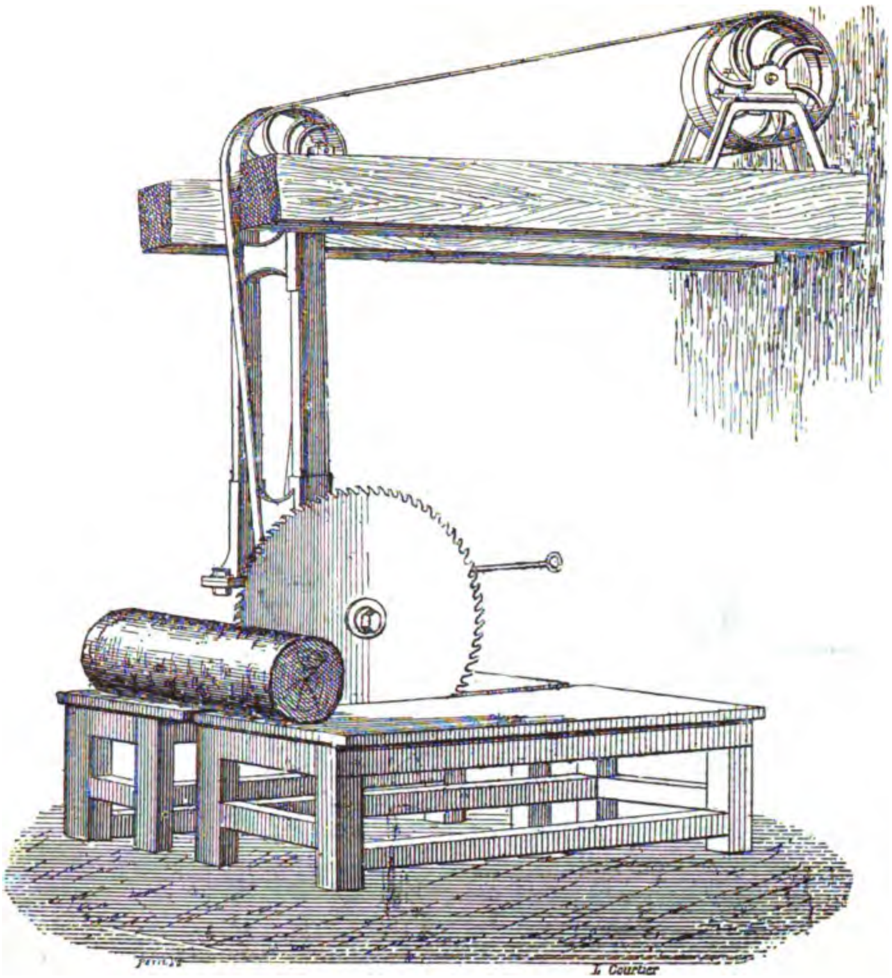


FIG. 138.

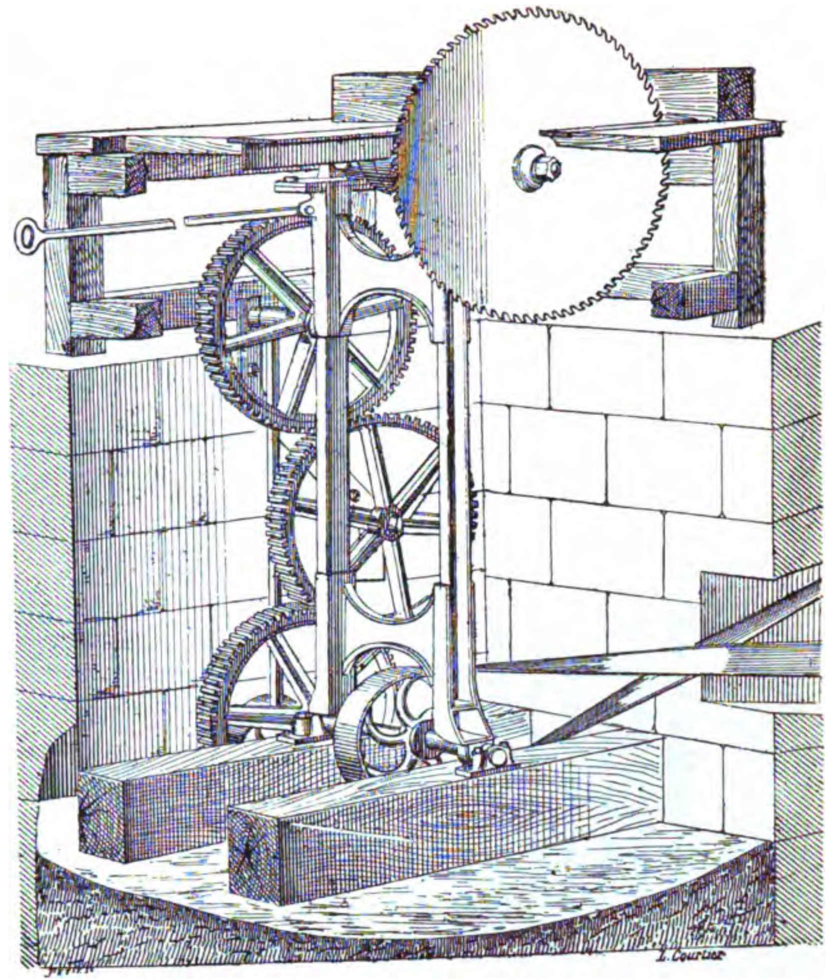


FIG. 139.

Cabinetmaking, in which absolute perfection in sawing is indispensable, employs horizontal sawing machines mounted in frames. In these machines the timber is fastened, or better clamped, on a carriage which runs vertically, while the saw cuts horizontally (Fig. 137).

This carriage can, more or less, approach the blade to regulate at will the different thicknesses of veneering or panels to be obtained.

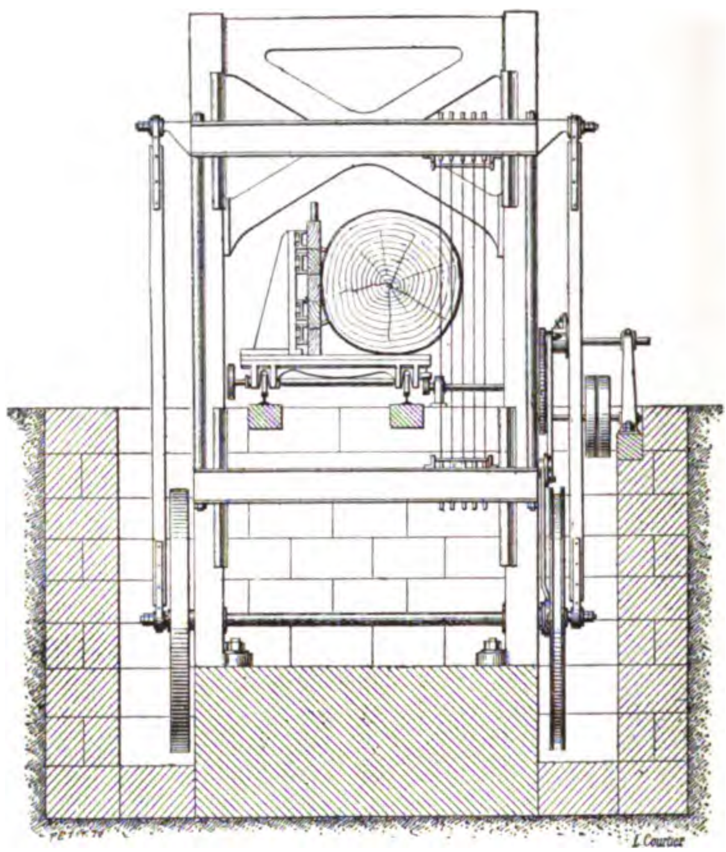


FIG. 140.

The size of the blocks of valuable timber is usually equal to 27 in.; two small pieces can be fastened to the side of each other.

The necessary strength is about 3 horse-power, and the number of saw strokes reaches 250 per minute.

As for the blades, they must be very thin and stiff; the teeth should be fine and pointed, and the cut should be fine.

This sawing machine may be used for cutting up blocks of ivory or hardened caoutchouc.

The other systems of circular saws or with endless saw bands are

especially employed for different joinery and cabinetmaking work, details of which will not here be given; as, however, circular saws sometimes serve to cut up timber, two examples of these appliances will be given (Figs. 138, 139, and 140).

RECAPITULATION OF THE DIFFERENT SAW-MILLS WHICH HAVE BEEN DESCRIBED.

Fig. 135. Many-bladed alternate vertical saw-mill, with carriage cutting two joists at one time.
„ 136. Alternate vertical saw-mill, with several straight blades; crank system and deep pit.
„ 137. Alternate horizontal saw-mill, for veneers, with upright carriage, for timber with a breadth of 27 in.
„ 138. Circular balancing saw-mill for truncating timber of large dimensions.
„ 139. Circular balancing saw-mill for truncating timber of large dimensions, with underneath movement.
„ 140. Many-bladed vertical saw-mill, provided with a system of dividing carriage, permitting at will the splitting in two of a tree of 27 in., and dividing it with precision into leaves, panels, and veneers.[1]

All the blades for alternative saw-mills must be in cast-steel, of very good quality, and flattened cold. They should be dentated conveniently, according to the timber for which they will be used, and tempered with sufficient annealing to permit of filing them.

The circular blades should be tempered rather hard, so that the edge of the teeth does not rapidly get blunt; it is also necessary that the filing should bite them so as to sharpen them and that the wrench should incline them to right or left to constitute what is called the track of the saw.

The dentation to be employed varies according to the nature of the timber, according as it is hard or tender, dry or green, shaggy or fibrous.

Generally the circular saws for timber have recumbent teeth when they are about 12 in. and less in diameter, and hooked when the diameter exceeds 15 in.

It is as well that all the teeth of a saw should work—that is to say, that they may all be situated upon the same circumference if they belong to circular saws, or that they may all be upon the same straight line if they belong to alternative or band saws.

To attain this result the circular saw should be made to turn against a sandstone; all the teeth which are too long are then ground until the shortest are reached. The teeth are sharpened with the file or millstone, the track is then given them in a regular manner by means of the wrench, care being had to leave some teeth untouched.

As a rule, the track is finer as the timber is harder.

Such are the principal rules which must be followed for the good maintenance of the blades. Upon the care exercised depends economy in the employment of motive power, the rapidity and perfection of the work, and the preservation and durability of the material.

[1] The machines just described are constructed by Messrs. Arbey.

TIMBER-CUTTING.

Certain tools must have been employed before the saw to test the quality of the wood. The key-hole saw is used to dissect pieces of timber so as to study them and determine if they contain flaws.

The adze is afterwards employed to shave the extremities of the pieces and to permit the study of the defects which the timber may present. This instrument is also employed to pare the surfaces.

The axe serves not only to fell trees, but also to lay bare the knots, and other faults. The knots are cleared by means of the gouge.

Augers are used to determine the nature and extent of the imperfections of the tree.

Once cut, the timber must be worked and assorted, according to the use to which it is to be placed.

Wood destined for heating purposes can be cut into cords of wood or into fagots.

The stems and branches are cut into quartered logs or billets, which are intended for firewood, and the smaller ones for fagots are cut into sticks.

The quartered logs or billets are then divided into sections, 1 ft. 3 in. long. For that the axe or saw is employed. This latter is preferable, inasmuch as it permits of the utilising of the entire trunk, which would not happen with the axe, which produces shavings. The logs not being of the same size, those whose diameter at the small end varies from about 1½ to 2 in. are called billets; the others, which are thicker, are resplit, then forming quartered timber.

Once cut, the timber is stacked upon as dry and united a soil as possible; it is then bound in cords, which contain an exact number of times the unity of measure, which is the stère. The cords are solely composed of quartered timber or wooden billets. Sometimes, though rarely, mixtures are made.

The bundles of wood composed of branches and twigs make up the fagots. As for the brushwood, these are fagots composed of twigs. The making of fagots is effected by means of sawing-trestles. As for the withes, they are made with all varieties lending themselves to torsion, like the yoke-elm, oak, hazel, birch, beech, dog-berry, and osier trees.

That timber which is not destined for firewood assumes the name *bois d'œuvre*. After felling, the woodcutter, by the aid of the axe or saw, removes portions from the trunk and top, which can only be utilised as

firewood. What remains is left uncleft, to be worked later in a single block or cut into logs of different dimensions.

Generally, building timber is preserved in its whole length. The oak, chestnut, and fir are especially employed for naval purposes; though for civil buildings the pitch, larch, elm, sorbs, poplars, etc., are utilised. The resinous varieties are always barked, for by so doing the ravages of insects are avoided.

Timber is also divided into *cord wood* and *floated wood.* The first has been transported in boat or carriage, and has not undergone prolonged contact with water. The second, on the other hand, is thus called because it is conveyed to its destination by means of floating on the water. For this purpose it is joined by the aid of ropes, in the form of rafts more or less lengthy, which are divided into building-wood and firewood rafts. As a rule, that wood which has not been floated is preferred for firewood, as it would not be so damp; but for building purposes it is the reverse, for as a matter of fact its stay in the water greatly contributes towards its preservation.

Timber destined for marine usages takes different names according to its dimensions and forms. As for oak timber-work, large timber is taken, that whose medium circumference exceeds 4 ft. 4 in.; the others are designated under the name of small timber-work.

Localities, diameters, and lengths cause the names which are given to the different pieces of fir-wood to vary. They are given in the following table:—

	Diameter.		Length.
	At Trunk End.	In Middle.	
	Cms.	Cms.	Metres.
Rafter	16 to 22	14	9
Single purlin	22 ,, 32	18	12 to 14
Double purlin	32 ,, 36	23	15
Beam	38 ,, 42	...	...
Holland	42 and above	...	...

Moreover, the wood is classified as cleft timber and sawn timber. The sawn product consists of planks of different dimensions. The cleft timber comprises staves, staff-wood, vine-props, hoops, laths, etc.

The sawing is generally done with the following varieties: oak, fir, pitch, sylvester pine, beech, and poplar. Sawings of oak and beech are done in the forests with long saws. The piece which should be transformed into planks is at first squared; the kerfs are then traced upon it, which will be followed by the saw. To take care of the quality and

beauty of the grain, it should always be sawn *sur maille*—that is to say, following the direction of the medullary rays. In taking this precaution, planks are also obtained which do not crack or warp so much.

As a rule, the dimension given to oak sawings varies according to the country and trees to be sawn. The merchantable plank, in which a part of the sapwood subsists, is most often 0·28 m. wide, by 3 to 4 mms. in thickness and 4 m. long.

In Paris the commercial dimensions are of two types, the scantling and the interjoist; these dimensions are summarised in the following table:—

	Length. Cms.	Thickness. Cms.
Large batten	333	11
Small batten	250	8
Doublet	333	6
Scantling	250	4
Ship-timbers	265	8
Interjoist	250	3
Rafter	80	8
Frieze	13 to 18	3
Panel	220	20 to 22
Batten	...	13 „ 15

With regard to the beech, it is cut into planks and beams intended for the making of furniture. The following dimensions are generally used:—

	Length. Cms.	Thickness. Cms.
Interjoist or leaf	216 to 243	31 to 33
Ship-timbers	165 „ 200	80 „ 110
Doublet or trap	330	75 „ 81
Quartlet	236	56
Small sawings	11 to 25	15

The planks of beech, like those of oak, are sold per current metre (about 3 ft. 3 in.).

The sawings of fir are usually 3·60 m. to 4 m. long, by 0·244 m. wide, with a thickness equal to 0·027 m. These planks are classified as follows:—

Dose or *dousseau*, first plank detached from trunk.

Rebut, opened or slit plank.

Ordinary plank, 4 m. long by 0·244 m. thick.

Reduced plank, same length by 0·216 m. wide.

Broad plank, 0·324 m. broad.

Usually the *cleft wood* is worked in forests, and is thus more easily

cut up. It is in the majority of cases the oak, beech, and fir which are employed for this purpose, when their fibres are straight and their texture homogeneous. Cleft wood is especially employed in cooperage work under the name *staff-wood*. It is converted into staves, which take the names of *intrados*, *lathing*, *cross-beams*, etc. The cooperage industry never employ wood still having sapwood; for this purpose the English oak and yellow chestnut-tree are preferred.

The length and thickness of the staff-wood are always fixed beforehand; the breadth varies.

Staff-wood can also be made of soft wood, but only when it is desired to make packing casks for dry merchandise.

After the staff-wood the vine-props are classed; the following varieties are employed for their manufacture: oak, acacia, chestnut, forest pine, willow, black poplar, fir, maritime pine, and aspen poplar.

The hoops for the tubs are made with elastic, resistant, and strong wood. For this purpose, young perches of chestnut, hazel, oak, nettle, yoke-elm, lime, cherry, or birch trees are split into two or four parts.

The other cleft wood, employed especially for cartwrights' work is the following:—

Hawthorn—Gears, cogs, and tool-handles.

White Service-tree—Same purposes.

Birch—Carriage-steps and poles.

Yoke-elm—Gears, cogs, tool-handles, levers, flails, and plough-handles.

Chestnut—Tool-handles.

Oak—Plough-beams, bodies of machines and carriages.

Maples—Handles of tools and whips, and bands.

Ash—Bodies of ploughs, poles, and shafts.

Beech—Implements of transport, axle-trees, wheel-fellies, bushel-making.

Nettle—Whip-handles, forks.

Elm—Wheels, naves, bodies of ploughs, and harrows.

Apple and Pear trees—Cog-wheels.

Robinia—Tool-handles.

Willow and Alder—Fork-handles, forks.

Fir and Pine—Tool-handles, machine pieces.

Linden—Chests, panels.

Preservation of Trees after Felling.

When trees are not worked immediately after being felled, certain precautions must be taken in order to preserve them.

As a rule, the woods should be cleared before the August shoots, if it is possible; a place would then be provided in the forest or upon its borders which will serve as depôt for the planks, bark, vine-props, etc.

As for the trees, long experience proves that bark is prejudicial to trees which are clothed with it when they are exposed to dampness. The sap ferments under this bark, and a multitude of larvæ of insects are soon seen to appear, which devour the sapwood. Trees cut in winter are less exposed to this fermentation than those felled in the spring or summer.

The following precautions must then be taken:—

(1) To place the felled tree in the shade.

(2) To bark it shortly after felling.

There is, however, an exception in the case of timber destined to be split into staves or cut into sabots, which must not be barked.

When carpenters' wood is squared immediately after felling, it is quickly dried, and it will not be long before a number of cracks and slits are seen in the wood. It is, however, observed that they are soon filled if the wood is plunged in water, and even if it is merely exposed to damp. To avoid this inconvenience, the tree is then left for some time in its bark before squaring it.

The best means of preventing squared, sawn, or cleft timbers from warping consists in piling them upon one another, care being taken to separate all the pieces by small wooden wedges, so that the air can circle round all sides.

As has been already mentioned, it is profitable to shape the timber before transporting it.

Transportation of Timber.

In mountainous countries, *slides* are used to bring the timber down, and if the distance is too great the timber is conveyed on sledges.

Trees felled in flat countries are brought on two pairs of wheels, to the axle of which they are attached by chains.

The timber, brought near to a river, is transported more advantageously by water, and preferably upon boats, excepting special cases where it is floated.

Floating in Sweden.

According to M. Paquet, important companies for the floating of timber have been formed in Sweden as a special means of transport of the wood exported by this country. These companies undertake, either with their own staff or by the employment of brigades of

jobbers, the floating, piling up, and distribution of the timber. This work ended, the companies make out, for each property, an account of the expenses they have incurred.

A certain number of these companies carry out the work of damming-up, conservation, and cleansing of rivers, etc. These works are often considerable, for the course of the rivers and streams of Swedish Nordland is most irregular. Large masses of rocks often stop the bed of the water-courses, forming barriers and rendering the work of maintenance very difficult.

From steep slopes the timber is brought down by means of rollers. On those which are not so steep, a fore-carriage of the sledge, drawn by horses, is employed. The timber is fixed at the large end upon the sledge, whilst the other, gliding over the snow, is kept in the correct track by a workman. As soon as the ground is not so steep, several large pieces of them are joined with chains upon two sledges, forming fore- and after-carriage, the distance of which is regulated according to the length of the timber. Two tools are employed to heave up and turn the logs round; one is a strong boat-hook (*wendehaken*) and the other a lever (*hedebaum*).

The timber is afterwards piled up on river-banks, each piece being marked with the proprietor's number.

Floating begins in the spring—towards the 1st of June. At this time a general thaw sets in, and the floods sweep down the streams and are taken advantage of. Indeed, the more rapid the current the less chance is there of the timber being lost *en route*. If, on the other hand, the current is slow the lumber is apt to run ashore and become fixed into river-banks.

In spite of all the precautions which accompany these manœuvres, it often happens that pieces of timber get stopped and jammed even in the middle of rivers. The timber is then heaped up, accumulating and finishing by forming veritable barriers, which are afterwards very difficult to demolish.

Another cause of loss arising from the breaking of timber is brought about by cataracts. In Norway one is sometimes obliged to have resource to dynamite to dislocate the masses of timber formed at the foot of cataracts.

For these different works it is evident that one is obliged to employ skilful and powerful workmen.

The salaries are as follows:—

Sea raftsmen (*sjöflottare*), who conduct rafts of timber, are paid for their labour 2d. to 2½d. per hour.

River and stream raftsmen (*strömflottare*) receive 2½d. to 3d.

Foremen (*vormann*) get 3d. to 4d.

Upon lakes the transportation of floated timber is carried out in two different ways. Upon the small ones, whose length does not exceed 10 kilometres, a large circular enclosure is formed with a ring of a hundred trees joined end to end. One side is open, and at this end about 20,000 trunks of trees are floated in. The ring of trees is then closed, and the wood cannot come out. To put the whole in motion, an anchor worked from a capstan is employed. This anchor is cast about 950 ft. in front of the raft, and the capstan is manned. The anchor, when reached, is taken up and cast farther on, and so on to the end of the lake. This method is called in Swedish *spelflottning*, or *the floating game.*

In floating the timber on larger lakes it is necessary to employ steam tugs.

Transplantation of Trees.

Some details may now be given upon an interesting point of the

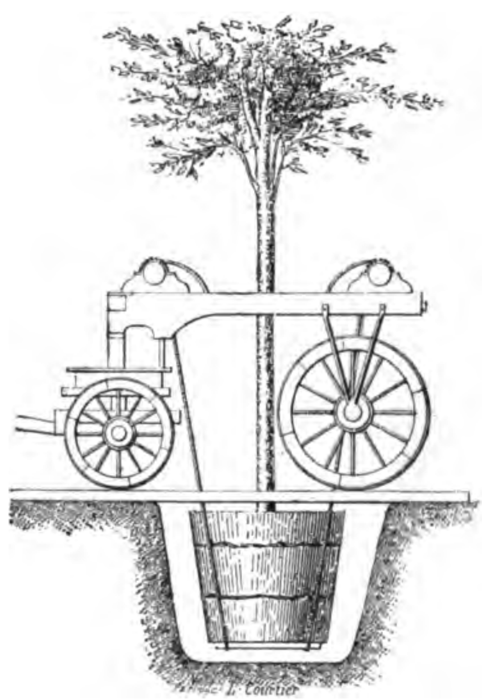


Fig. 141.—Tree Transplanting (side view).

transportation of trees; we will speak of the displacement of entire trees for the purposes of transplantation.

In this case special carriages are employed, notably at Paris, which can be classed in three categories—

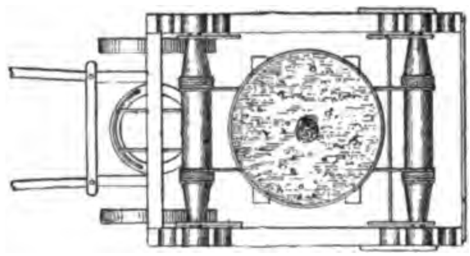
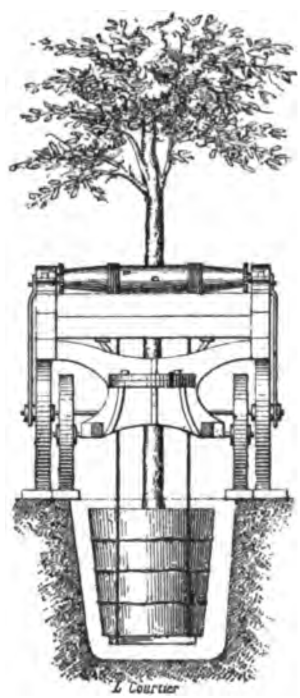


Fig. 142.—Plan of Small Carriage.

(1) The small carriage (Figs. 141, 142, 143, 144), which represent a side view, a plan and two elevations of the fore-carriage and after-carriage of the waggon.



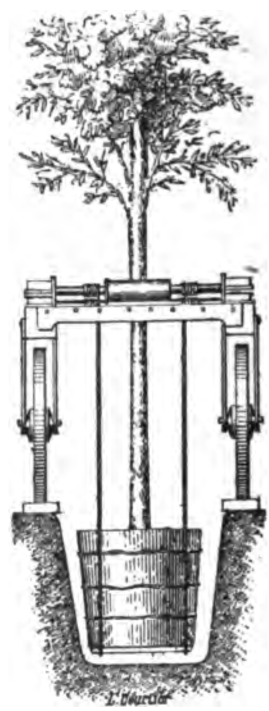


Fig. 143.—Elevation of Fore-Carriage. Fig. 144.—Elevation of After-Carriage.

(2) The two-horse carriage, of which Figs. 145, 146, 147, and 148 represent a side view, a plan and two elevations of the fore-carriage and after-carriage of the waggon.

(3) The large carriage built of iron and steel.

Figs. 149 and 150 are a side view and a plan of this apparatus.

When these carriages are employed for the transportation of trees, care must be taken, as far as possible, to preserve the roots, especially those presenting the most fibrous parts. The clods of earth which accompany the tree must therefore have as much room as possible.

For caducous-leafed trees, the dimension of the clot of earth varies from about 30 in. to 8 ft., according to diameter and age of the trees.

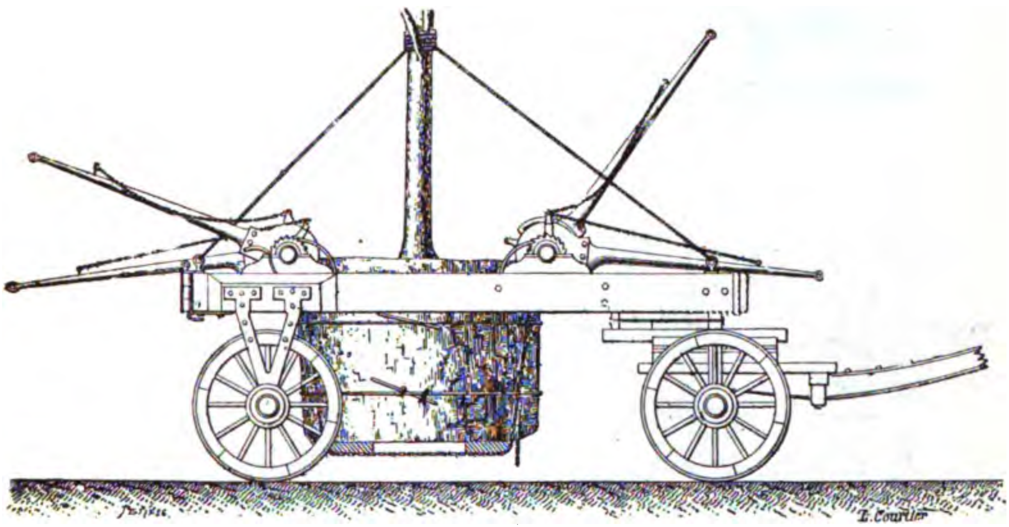


Fig. 145.—View of Profile of Two-Horse Carriage.

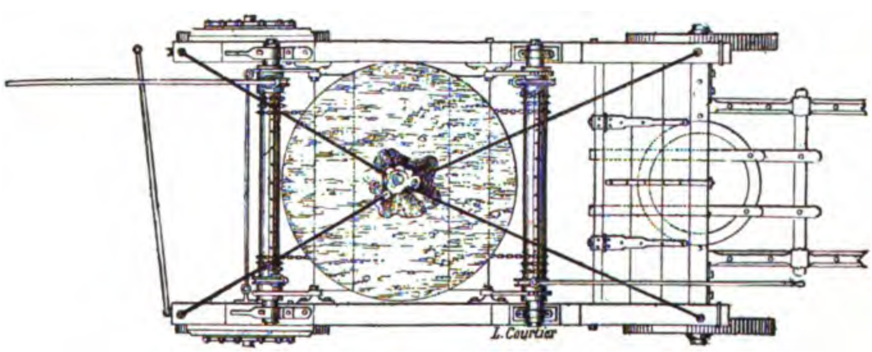


Fig. 146.—Plan of Two-Horse Carriage.

With regard to trees with persistent leaves, whose roots are re-formed less easily, very large clods of at least 6½ ft. in diameter are always necessary, in order to favour the renewal of them, however healthy the trees may be at the time of removal.

To transplant the trees by means of these carriages, an annular excavation is at first made around the trunk and at a certain distance from its root, in order to form the clod. In proportion as the digging gets deeper, the clod is enclosed, according to the more or less compact

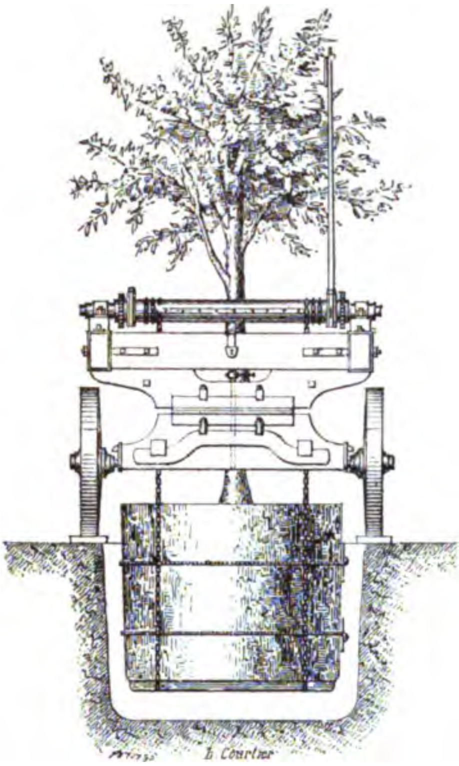


FIG. 147.—Elevation of After-Carriage.

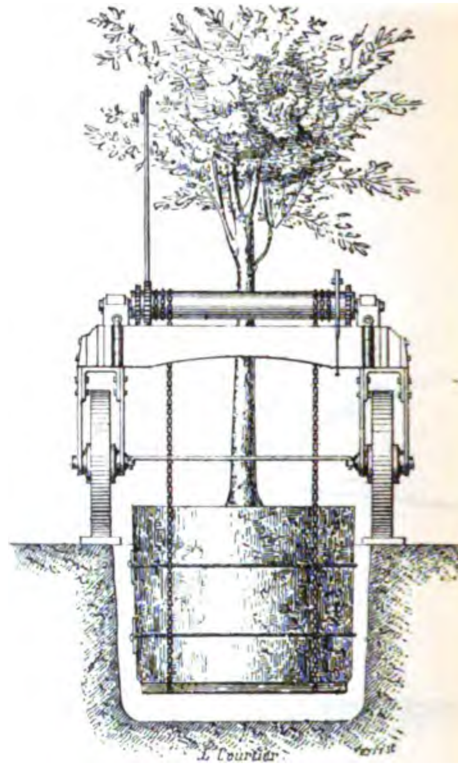


FIG. 148.—Elevation of Fore-Carriage.

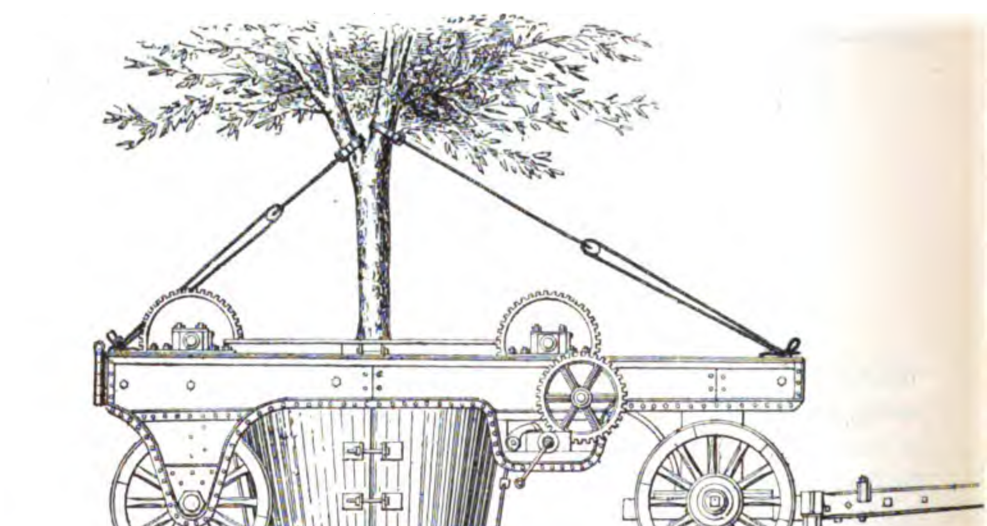


FIG. 149.—View of Profile of Large Carriage.

nature of the soil of which it is formed, either with entwined branches or with a wooden hooped tubbing with iron bands, tightened by means of a screw.

The tree is then supported by the aid of shrouds, and the clod of earth to which it adheres at the root is detached, by passing wash-boards underneath, when it is fitted in a wooden tub; or by twining and tying the branches, when it is only surrounded by boughs.

The tree being thus prepared, two boards are placed over the hole, on to which the carriage is pushed, so as to clasp the tree in the four beams forming the frame of the carriage. The rear beam is, moreover, attached to the lateral traverses by a hinge, which permits of

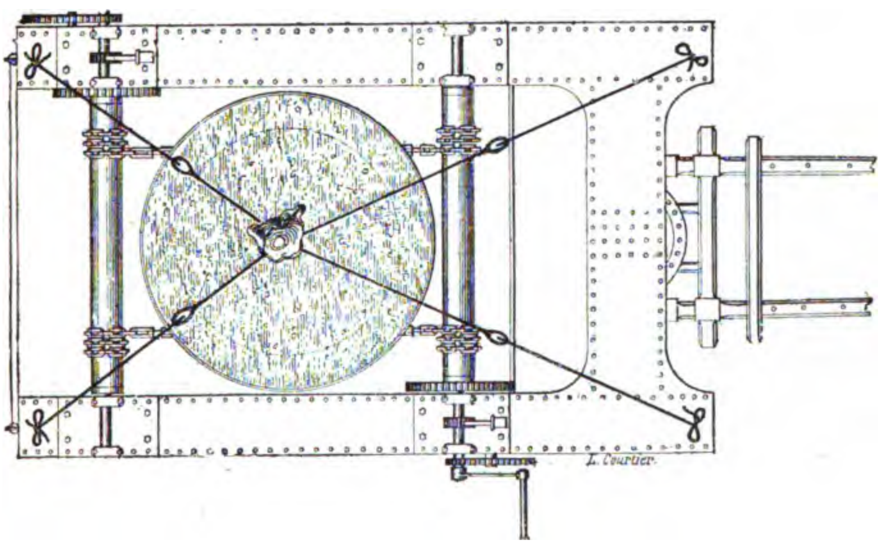


Fig. 150.—Plan of Large Carriage.

manœuvring it at will, and of thus opening for the trunk of the tree a passage which allows of its penetrating into the frame. The clod is then raised underneath by the cord or the chain rolled upon hand-winches of the appliance. A rotating movement is afterwards given to these, and the tree, with the clod, is raised above the soil. The traverse of the rear of the frame is put into place; the shrouds, moored to the principal branches of the tree, to keep it straight and rigid, are attached to this frame.

When these different operations are finished, the carriage is drawn and the tree transported to its new destination. To lower it to the place it is to occupy, the same processes must be employed as for raising it from the soil whence it has been taken. The cavity prepared for its reception must always be furnished with good ground,

properly beaten down and watered as it is thrown into the excavation.

The cost of transplanting a tree a distance of 3 to 4 kilometres, varies for the small carriage from 16s. 8d. to 33s. 4d.; for the medium carriage, 33s. 4d. to 62s. 6d.; and for the large carriage, which often requires nine horses to drag it along, from 62s. 6d. to 100s.

Exploitation of Algerian Forests.

This exploitation is regulated by the conditions at which the work is contracted for, which, excepting some variations, are the same as in the capital.

Sale of the products is made by public auction.

From the exploitation point of view, the Algerian forests may be divided into two categories—

(1) Forests stocked with varieties other than the cork-tree.

(2) Forests of cork-trees.

Forests of the first category provide firewood, bark, and industrial timber.

Building timber is obtained from forests situated in very rough regions not yet served by roads and railways. Their exploitation is therefore only effected in a very disadvantageous manner.

The development of telegraph lines in Algeria was, in 1888, about 8000 kilometres, which represents about 100,000 posts in course of service. We may take, as average figure of the annual consumption, for ordinary repairs, 6 per cent. of the number of the poles in use—namely, 6000. By adding 1 per cent. in view of the progressive development of the secondary network of wires, we arrive at 7000 as the number of posts to be furnished annually.

In ten years from 1880 to 1890 the forests of this country furnished 17,000 posts, or 1700 per year. It is therefore seen that the production should be quadrupled if the importation of timber from the capital is to be given up.

It must also be said that the timber generally employed for this purpose—the Aleppo pine—is appreciably denser than the pines or firs coming from the docks at Algiers. Its durability is likewise almost indefinite in a number of soils, and as a rule it is at least five times greater than that of the telegraph poles employed in France.

Exploitation of the Cork-Tree.—It has been seen that the cork-tree forests in Algeria occupy an area of about 1,132,500 acres.

Before giving saleable cork, the tree must undergo a first operation,

consisting in stripping off the suberose bark which is produced naturally. This operation is called *démasclage* ("stripping").

To strip a tree, one commences by making, at a certain height, a circular groove in the bark, with the precaution not to exceed the suberose layer and not to make an incision in the *mère*. A similar incision can also be made at the foot of the tree. The bark is then split lengthways, the same precautions being taken, and, commencing from the top, the cork is detached from the *mère*, which one continues to raise. As soon as the bottom of the tree is reached the cork is detached by means of very clean breaking.

If the tree is not more than about 1½ ft. in circumference, the bark is removed in a single piece, in the form of *canon*; beyond this dimension two or three slits are made instead of merely one, and the cork is then raised in planks.

This operation, theoretically very simple, requires great care and skill. It must always be entrusted to skilful workmen, as the slightest fault will cause the death of the tree. Success and the future of a cork-tree plantation depend upon proper stripping.

This last operation must be done when the tree is in full sap; it is only at this time that the cork can be easily detached. When the sap is not in full activity the taking away of the cork may be accompanied by the dragging away of the *mère*. The same effect will be produced if stripping is commenced too soon; for example, at the period of the first rising of the sap, when the liber is not sufficiently impregnated; this latter, in fact, rises then very easily, on account of its adhering but slightly to the sapwood; now, as soon as the liber is drawn, or even only disengaged, the cork ceases to form.

The workman assures himself often by previous sounding that the tree is sufficiently in sap to undergo stripping. In this case the side exposed to the north must always be sounded.

By too early stripping the trees would be liable to mutilation and consequently die.

Once opened, the stripping campaign should be carried out very rapidly, and finished, if possible, before hot weather sets in. During very dry weather the circulation of the sap diminishes; the cork is then removed with difficulty, and the work of stripping is retarded. Towards the end of summer one commences to dread the violent winds and, a little later on, rainy weather, which are dangerous for those trees which have been only recently stripped.

With the lowering of the temperature the movement of the sap is slackened, when stripping is often attended with great difficulty.

In this case work must be stopped and a more favourable moment awaited.

Cork is not, properly speaking, an organ of vegetation: it is merely a protective covering.

When a part of this covering is removed by stripping, an abundant evaporation is manifested on the surface of the part made bare; trouble in the function of vegetation results; but if the operation has been made under favourable conditions, a fresh epidermis is rapidly formed, because the exterior part of the *mère* becomes dried, evaporation diminishes and again becomes normal. If stripping has been too extensive, and if the tree has not sufficient vigour to make up for the loss of sap, it will perish of necessity.

It is, therefore, experience alone which can indicate in what proportions stripping should take place. A tree whose summit is regular, well leafed, in a word, a vigorous tree, would be able to undergo severe stripping. It will not be the same when the oak is of a poor description.

As a rule, good bearing trees and those of average size can be stripped up to the growth of the principal branches. The stripping of the trees which have a tendency to produce inflated cork should be raised, and in damp ground the stripping will always be able to be raised higher than in dry and arid soil.

Usually, the workman who performs the stripping operation, after having detached the cork from the tree, burrows the trunk from top to bottom by incisions made in the *mère* by means of a very sharp knife, these incisions traversing the *mère* and penetrating as far as the sapwood. The object of this is to give play to the crust and to prevent the production of cracks which would otherwise form on the surface of the reproduction cork. It would, however, be wise not to allow these incisions to penetrate as far as the sapwood.

When it is desired to gather the reproduction cork, one proceeds exactly the same as for the stripping. In a forest in course of exploitation in another way, these two operations are practised at the same time; the same workman raises the reproduced cork and proceeds to the stripping of the young trees.

The most vigorous tree after stripping is found for a certain time in a relatively unhealthy state, and its convalescence lasts until a new epidermis is formed over the stripped part. During the convalescence it is very sensible to atmospheric influences.

Trees recently stripped are sensible to the effects of the sirocco for at least a month after the operation, and the destructive action is so deep-

seated that trees struck dead are dried almost immediately. It therefore follows that stripping must be suspended during the time of the sirocco and in the rainy season.

A "stripping" timber-merchant's staff is composed of a chief or foreman, assisted by five European overseers; each overseer directs ten workmen "strippers," who are followed by four porters.

To operate what is called the *battue*, the overseers arrange their "strippers" upon the same line, spreading them out or placing them nearer together, according to the nature of the forest and uneven nature of the ground. They afterwards direct the progress by going along the line of front, superintending the work of each and verifying if there are no trees forgotten in the work of stripping or gathering. The porters come behind, collecting with cord the product of one or several trees and transporting them over the stripping excavations.

It is generally estimated that a good workman can strip thirty trees daily.

The quantity of cork furnished by a tree at each gathering varies according to its dimensions, the extent of surface of stripping, and the nature and thickness of the cork gathered. A young cork-tree produced at the first gathering from 3 to 4 kilogs., whilst an old tree may give as much as 150 kilogs., though this yield is exceptional.

CHAPTER XVI.

DAMAGE CAUSED TO WOOD.

BEFORE considering the methods of preservation, properly so called, of timber, it must be pointed out what are the principal causes of damage or destruction of much of the timber upon the spot—namely, the trees—and of the felled timber, ready for use or even during this employment.

The means of preservation or defence vary according to the nature of the destructive agents or the species of enemies attacking the timber. These agents or enemies are man, animals, plants, and certain physical phenomena.

It is not our object to dwell upon the damage done by mankind to woods or forests; this subject has almost solely to do with the exploitation of forests. Let it suffice to say upon this special point that man can harm forests either by illegally taking possession of the forest products and encroaching upon the wooded soil, or by stripping and damaging the forests whether by ignorance, negligence, or misfortune.

As for the damages caused by animals, these affect our subject more closely, or at least those due to the ravages caused by insects.

The animals which injure forests are numerous; quadrupeds, birds, and insects all make war on the trees.

Domestic animals do the most damage, and among these the goat figures in the front rank.

Too much game is also very prejudicial to forests. Rodents, such as squirrels, mice, etc., feed upon seeds and also nibble the buds.

As for birds, they principally attack seeds. But by far the most dreaded enemies, as much for the growing tree as for that which has been felled, are undoubtedly insects.

THE DAMAGE DONE BY INSECTS.

The ignorance which still prevails of the habits of the majority of insects in the larvæ state shows that we do not yet know all those

which are so destructive to forests, as well as the nature of the havoc they commit.

The ravages caused by insects are of different kinds. Some pierce into the wood of trees whether these be alive or dead, others nourish themselves on their fruit; a large number devour or suck the leaves of them. Several, such as the majority of the Coleopteræ, Hemipteræ, and Hymenopteræ, live separated, and only attack the wood individually.

Others, on the other hand, such as certain Lepidopteræ, are gregarious, and devastate, in the caterpillar state, the woods and forests, where they cause incalculable damage.

Some details will now be given as to the principal destructive insects.

Among the *Coleopteræ*, we put first the cockchafer, which devours the flowers and leaves of the oaks and beeches. The larvæ of this insect, known as white worms, eat away at the roots of trees, causing them to perish.

There are several varieties of cockchafer, the principal being the *Scarabæus melolontha* and the *Scarabæus fullo.*

Afterwards come the *Bostriche typographe*, which is brown, velvety, with striated elytrons, truncated and dentated. It is in the state of larvæ that this insect attacks different trees and becomes quite a scourge for forests of firs and pitch, in creeping between the tree and the bark, and there boring out a multitude of passages which stop the circulation of the sap.

To guarantee forests from attacks of this insect, the multiplication of its enemies must be encouraged, such as night birds, the woodpecker, tomtit, and chaffinch.

The unhealthy, damaged, or falling trees are felled promptly and in all seasons, or, at any rate, these latter are barked.

The shoots are extirpated at once after felling, or they are stripped as soon as possible of their bark. The trees attacked by insects are then attentively sought after, and are recognised by the yellow colour of their cones; these trees are then felled and immediately barked.

The *Bostriche of the sylvester pine* is very small, chestnut-brown, with red abdomen. Like the preceding, it attacks trees whether alive or dead, especially old trees.

The *destructive Scolyte* is black, brilliant, and dotted; the feelers and legs are of chestnut colour. The female, in the perfect and fecund condition, pierces the old bark, especially that of the elm, as far as the liber; it then rises from bottom to top in the liber and sapwood in a

passage that it forms there, being nourished upon its tissues, and deposits in this passage, one upon the other, its prolific eggs. When the laying of eggs is finished, it dies at the end of the passage, or comes out by another hole to die elsewhere.

The deposited eggs are hatched; the larvæ are also nourished by the liber and sapwood. They bore from each side of the maternal passage, closely against each other, thus forming, with the central passage, a sort of herring-bone pattern, which is perceived when the bark detached by these larvæ is removed. When they arrive at the term of their growth, they become transformed into perfect insects, piercing the bark, spreading outside, and coupling, and, when pregnant, the females, in their turn, come back to pierce anew the bark of the tree and deposit there a fresh series of eggs, thus recommencing their mischief.

Scolytes, like other parasites, fall less upon healthy trees growing vigorously. It even happens, when they have attacked vigorous trees, when the eggs are deposited there and even when these eggs are hatched, that an abundance of sap, in the spring time, surrounds either the eggs or larvæ, swamps them and kills them, the trees thus escaping the attacks of the insects. They, however, experience a slackening in their vegetative force; and if the attacks are renewed and multiplied, the trees fall insensibly in a state of languor, which more particularly attracts new parasitic legions.

To arrest the ravages of scolytes upon elm-trees, the breeding places are sought of these insects, then, by opening these places to the air, the insects are killed before they have a chance to reproduce themselves.

Besides the scolytes, there is another species of insect which attacks the trees of forests. These are certain *Lepidopteræ*, and among others two nocturnal butterflies, the *Cossus* and the *Zeuzera*. The female of these two varieties, when pregnant, deposits its eggs upon the bark. Young caterpillars, instead of nourishing themselves upon the leaves, even feed upon the wood. They force themselves under the bark, afterwards entering the body of the tree, where they form holes which not only impair the quality of the wood, but also arrest its vegetation, even shortening the life of the tree if they are multiplied. General barking has the advantage of laying bare the holes made by these caterpillars—holes which a simple research sometimes fails to discover. Once these holes are discovered, the caterpillars are killed by means of an iron wire, which is forced through the holes, or even by means of the application of a layer of tar. By this latter operation the holes are stopped up and the caterpillars perish, either through privation of air or because the oil of

tar reaches them and stops up their respiratory spiracles, or because the tar, like the oil, acts in a toxic manner upon the insects.

This coating of tar has still another advantage—that of driving away, on account of its odour, the insects, and thus preserving the tree against renewed attacks. Lastly, in covering the wounds and the woody matter laid bare, where all the bark has been destroyed, it preserves it from contact with the air and especially from dampness, preventing it from decomposing and avoiding a fresh cause of destruction of the tree. Indeed, when the woody matter of the trunk is destroyed, the bark supports the weight of the top of the tree with difficulty, and it does not then require much wind to break it. The tar, for the rest, does not prevent the sappy pads from forming, and it does not appear to produce any regrettable effect upon vegetation.

Other Lepidopteræ whose ravages are greatly to be feared are the *processionary Bombyx*, *Pyrale*, and *Fidonia* of the pine.

With regard to the damage done by the processionary *Bombyx*, *Pyrale* of the shoots and buds, and *Fidonia* of the pine, it is found, according to M. Couturier, that the nests of bombyx appear in the autumn, from September to November, according to climate. Always completed at the time of strong frosts, they are purse-like in construction towards the end of the branches. They are found upon pines from seven to eight years of age. The invasion is more or less extended, but they are found almost each year from the littoral as far as the Alps.

Caterpillars are hatched in early spring. At first very small and tenuous, like the points of needles, they are, at the end of a month, about 3 cms. long by 4 mms. thick. In April they attain their maximum development; about double the preceding dimensions, they are velvety and reddish, and have sixteen claws. Towards the month of May they leave the nests, after having devoured the cones and the bark of the boughs to which these nests are fixed, and they roam processionally from one pine to another to continue their havoc.

Before the definite abandonment of the nests, they already make partial incursions outside.

At the end of June the last transformation is effected; neither caterpillars nor larvæ are found. The purses are full of the *débris* of the immediately preceding envelope.

This caterpillar is easily destroyed in the purses, which are slightly opened and into which oil is poured.

If the invasion is considerable—that is to say, if it attacks greatly pines near one another—there are, on an average, one or two purses upon each.

In this case a workman can destroy per day 600 nests on pines from 3 ft. 3 in. to 6 ft. 6 in. high, and 200 only if the trees are taller.

It often happens that, as a consequence of more backward hatchings, purses are formed in the spring; in this case they are smaller, not so thick, containing caterpillars less developed than the others.

The *Pyrale of the buds* appears in the spring, at periods varying according to places.

The invasion, once commenced, goes on rapidly. Four or five days after the appearance of the pyrale the caterpillar and the chrysalis can be found on the same pine.

The *Pyrale of the shoots* appears later—in June—when the sap has been active for some time; the buds attacked then become crooked in a characteristic manner.

The shoots crossed by the pyrale become dried up and die, the tree is deformed, the more as the insect frequently attacks the top. It is by no means rare to find from six to twenty of them upon an average-sized tree, and the plantations are invaded from the age of six to seven years.

The caterpillar is olive colour, 1 to 2 cms. long by 2 to 3 mms. thick. The chrysalis is chestnut colour.

The insect, in introducing itself at the bottom of the buds, determines a flow of resin, which denotes its presence. To destroy it the bed of resin is removed with caution, and through the hole that the insect has burrowed a fine point is thrust in order to kill it.

A workman can kill about 5000 of them per day. But it is often quite advantageous and more expeditious to merely cut the bud attacked and to burn it, providing it be not terminal.

The pyrale attacks the black as well as the forest pine.

The caterpillar of the *Fidonia* of the pine, 3 cms. long by 4 mms. thick, is green, with two longitudinal rays of a dirty white, and the top of a brilliant black. It attacks the forest, black, and laricio pines, from eight to fifteen years old, devouring all the cones. When a tree is approached upon which it is found, they rapidly mass together so as to form a sort of pellet, twisting and twining in every direction; when one gets farther away, they spread rapidly afresh on the branches.

To destroy them, the plants are slightly shaken so as to make the caterpillars fall off, either into "receivers" filled with acidulated water, or upon linen, where they are collected, to be either drowned or burned. They can thus be destroyed to such a degree that, the following year, there is no longer any damage to be recorded.

The *termite* of the Neuropteræ order is also a dreaded insect, attacking

the most solid timber work. In Algeria entire villages are often threatened in consequence of its presence in dwellings. The African natives call it *timedi*; its length is about 10 mms. Its head, which is reddish, resembles that of the ant.

This insect attacks carpenters' work by gnawing it, even penetrating into stone and there multiplying in profusion. A house invaded is condemned to tumble down. It also attacks vestments and certain fruits, like dates.

The mandibles are very strong; all means attempted for its destruction have remained without result. Washings and coatings of lime have no effect.

The termite is common at the Cape of Good Hope and in the interior of Africa; it also exists in the west and south of France.

This insect respects the exterior teguments of objects, though it completely destroys the interior of them, so that most often its destructive action is only perceived when it is past remedying.

The *Limnoria terebrans*, a small crustacean 4 mms. long, is furnished with two claws, allowing it to hang from wood like a bat.

This animal can easily move about by the aid of two rapidly moving "fins."

More dreaded than the taret, the *Limnoria terebrans* can, indeed, not only live and develop in clear water, but also in mud or wet embankments.

One can therefore only struggle against the destructive effects of this animal by creosoting the pile-work, or injection by means of corrosive substances or *mailletage*, which is an operation consisting in forcing nails very close against each other in the surface of the wood desired to be protected.

Almost all the forest species may rapidly become the prey of this small crustacean, with the exception of the *Eucalyptus rostrata.*

DAMAGE TO THE CORK-TREE.

Like all the forest trees in general, the cork-tree nourishes a large amount of insects, living at its expense upon its leaves, in the wood bark and even the roots.

The following are the most harmful:—

Caterpillar, devouring the leaves.

Worm, which eats the wood.

Ant, which pierces the cork.

The Caterpillar.—Among the numerous varieties of Lepidopteræ

caterpillars living upon the leaves of the cork-tree, one only deserves attention, on account of the enormous ravages which it makes; it is the caterpillar of a nocturnal butterfly—the *Bombyx dispar.* This caterpillar, fairly bulky, may reach 5 cms. long; it appears in the spring often in enormous quantities and principally in young plantings, which it devours even to the last leaf.

When a tree is stripped, they pass to the neighbouring one, thus continuing their ravage up to the time of their transformation, which takes place at the commencement of June. The butterfly is hatched three weeks afterwards, the female of which is larger than the male and differs besides in the colour, whence its name.

During the day the female, applied against the trunk of the trees, deposits there, generally at the bottom of the branches, its agglomerated eggs, in oval plates and covered with a thick greyish-yellow felt. Hatching often takes place the same year; a second scourge, more dangerous than the first, is then produced.

The devastations of the caterpillar of the *Bombyx dispar* spreads sometimes over very large areas, and in Algeria cantons of 1500 to 2000 acres are often seen stripped of their foliage in the space of a few weeks; at a certain distance the denuded trees present the appearance of a forest ravaged by fire.

Those trees whose leaves have been devoured by caterpillars do not appear to suffer the first time; the foliage soon re-forms, but it is not the same if this is repeated the following year, or, what is still worse, a second time in the same year. In this case the tree, exhausted, scarcely replaces the foliage of its summit, vegetation becomes languid, and a certain number perish.

It is seldom that caterpillars present themselves three years in succession in the same canton.

It is generally admitted that each invasion of caterpillars creates a loss of at least half of the annual production of cork, delaying the gathering for a year.

The caterpillar of the *Bombyx dispar* has sometimes, though erroneously, been confused with that of the *processionary Bombyx,* which has previously been dealt with.

The Worm.—Insects which, under the form of caterpillars or larvæ, exercise their ravages upon the interior of cork-trees belong especially to the Lepidopteræ, Coleopteræ, and Hymenopteræ orders. The caterpillar of a Lepidopteræ, the *Cossus* spoilt-wood and the larvæ of certain Coleopteræ of the Longicorn family, alone deserve our attention.

It often happens that young and vigorous oaks which have been "stripped" a few years ago perish suddenly and die in a short time, without any apparent motive to justify this mortality. Corkers then say, and with reason, that these trees "have had the *worm*."

The *Cossus ligniperda* is a large nocturnal butterfly, with ash-grey wings and thick body. The female's abdomen is furnished with a tubular terebra, by means of which its eggs are deposited under the bark of the trees. This butterfly is equally distributed in Europe.

During the day the female remains motionless at the foot of the trees. In the month of July it deposits, by means of its terebra, its eggs at the bottom of the crevices of the bark, and fixes them there, almost level with the soil, by means of a viscous liquid. Shortly afterwards the young caterpillars are hatched and are of a bright rose colour on top. They immediately make a passage as far as the sapwood, nourishing themselves for some time upon the surface by destroying the liber, hollowing superficial passages, narrow at first, but enlarging by degrees. Arrived at a certain size, the caterpillars quit the sapwood and penetrate into the interior of the tree, where each one hollows, axially, a principal passage, furnished with several lateral passages directed towards the surface of the bark.

At the adult age the *Cossus* caterpillar sometimes measures a decimetre long by about 30 mms. thick. It is provided with strong mandibles, which serve to attack easily the wood fibres.

When the size reached by this caterpillar is considered, as well as the development and width of the passages which it burrows, an idea is obtained of the ravages which a colony composed of several dozens of this species of enemies can make upon the interior of a tree.

A tree of good dimensions may resist for some time, but a young subject is promptly killed; the *Cossus* caterpillar must therefore be considered as very harmful.

This butterfly usually attacks young and vigorous trees. Old trunks are generally inhabited by the larvæ of several large Coleopteræ of the Longicorn or Capricorn family. The larvæ of the *Cerambyx* is the most common; in size it is about the same as the *Cossus* caterpillar. This larva burrows, in the interior of oaks, sinuous and slightly flattened passages, the size of which reaches 3 cms.; it does not live as long as the *Cossus* caterpillar, and is less to be feared.

The perfect insect comes out through a lateral passage opening at the exterior by a hole, which is often the size of one's finger.

Old oaks are frequently met with whose trunk is completely studded with holes upon those parts stripped of their bark; such trees no longer

have vigour, and only produce a thin and not very abundant bark; what it is best to do is to fell these trees as quickly as possible, to clear the forest of them and make room for replantings.

The Ant.—As a rule, ants are considered as being more useful than otherwise for forests. But there is one of them in Algeria, the *wood-gnawing ant* (*Formica ligniperda*), which is not content with dead wood, and which attacks the cork, where it is established often in large colonies.

This insect does not work in the open air, nothing in particular denotes its presence on the exterior, and one has to remove the cork to get an idea as to the ravages. Upon the "stripped" trees the ant enters by the slight opening existing between the male bark and that of reproduction; crouched under the male cork, it begins to establish its first passages by profiting by the medullary canals, of which the disaggregated cells offer an easy progress.

It afterwards advances by hollowing, according to the limit, annual beds, and the different storeys of its abode are thus found arranged concentrically. The rooms or cells are separated by partitions or thin columns towards the centre, and whose thickness diminishes unceasingly in proportion as the column increases.

By this incessant work the cork of certain trees is studded with holes to such an extent that it has barely any consistency. The naturally porous corks, whose numerous medullary canals facilitate the work, are most exposed to the attacks of ants.

The following are the measures of protection:—

One should hasten to clear away all bad trees, and destroy by fire all the old timber which might serve as a retreat for ants. At the time of stripping care must be taken to see that no old bark be left adhering to the foot of the tree, and that on the top the detachment of the bark should be done so as not to remove the male cork remaining above, for it is always here where the insects try to take refuge.

The insects living upon the roots of the cork-tree are not very important, only a larva of the small cockchafer can be cited which often attacks the roots of young plants.

Lastly, the diseases noticed upon the cork-tree have as their causes either a vicious treatment on the part of man, attacks of insects, or atmospheric influences.

As a rule, to prevent the ravages of insects, those animals are multiplied which are enemies to them and whose presence is not prejudicial to the forests. A very active surveillance must be kept the

whole year, but especially in the spring; one avoids felling the trees in sap, especially the resinous ones; or else those that have been felled or blown down by the wind are barked at once. The shoots of these trees are extirpated at once, or at least they are barked; and the trees are felled which are isolated and infested by insects, and a deep ditch is dug around the tree that is attacked.

We will not dwell upon those plants which are harmful to forests, their number being very great. The following only will be cited:—*Common broom, bramble of Mount Ida* or *raspberry-bush, hedge bramble, blue-berry bramble, hedge clematis, tree-ivy, common sweet-heather, myrtle cowberry*, and *holly*, etc.

DAMAGE DUE TO PHYSICAL PHENOMENA.

It only now remains to make mention of several physical phenomena harmful to forests.

Some are due to climate, others to the state and nature of the soil, or to its topographical configuration.

The first, due to climate, are: cold, heat, wind, snow, hail, and lightning.

Cold is generally harmful to a rather large number of woody plants, and it is especially by frosts whence it arises that this atmospheric phenomenon causes most damage to our timber.

Severe frosts, indeed, cause the large trees of our forests to split and break, and produce defects known under various names.

Forests are guaranteed from the effects of cold and frost, or at least their disastrous effects are attenuated, by reasonable and skilfully-directed handling.

Heat is prejudicial, especially through the dryness it occasions. Intense and prolonged heat, by drying the soils, especially those which are light, dries up and causes the seeds to perish, deprives the young plants of their proper dampness, and they consequently die. It also exercises a baneful influence upon the trees, which it dries up and causes the cortical covering to crack.

Wind, especially hurricanes, creates immense damage in our forests, principally in those which contain high lofty trees, which they break and uproot. The disastrous effects of the wind are to be partially avoided by carefully studying their nature, frequency, and ordinary direction, and by intelligently directing the management and cutting of the timber.

Snow often causes damage in very thick forests, especially in those of resinous trees, by accumulating upon their summit and breaking their

branches. Sometimes the snow, after being thus accumulated upon the top, falls in a mass, breaking the young plants. Forests are preserved as much as possible from the destructive action of snow, by not planting the trees too close together, and at the same time skilfully practising clearings and loppings.

As for the physical phenomena due to the nature or configuration of the soils, they are often the more dreaded, as they sometimes extend their ravages over a considerable surface of ground.

To the number of these phenomena can be ranged the overflowing or stagnation of waters, the moving sands, avalanches, and landslips. The different means of preservation in various cases have already been shown in previous chapters.

DAMAGE TO TIMBER IN FOUNDATIONS.

This survey of the different causes of deterioration of timber may be closed by showing what often occurs, from this special point of view, in foundations.

It has for a long time been admitted that timber constantly placed under water in the foundations of hydraulic works is preserved without alteration in an indefinite manner.

Hervé Mangon, whose attention had been drawn to this point, has stated precisely, by concluding analyses, one of the causes of destruction of timber in foundations.

A first specimen was part of the *piles of the foundation of the Bridge of Mejin, cut at about 8 ft. below the low-water mark.* In the damp condition this timber did not present any resistance; dried, it showed strong contraction, and was of rather long durability. It was of a deep brown colour, and appeared deeply altered.

An elementary analysis of this sample has given the following results :—

	Per cent.
Carbon	43·890
Hydrogen	7·825
Nitrogen	0·460
Oxygen	39·720
Ashes	8·105
	100·000

On the other hand, the analysis of the ashes, added to the preceding figures, permits of the composition of the entire mass being established as follows :—

	Per cent.	Per cent.
(1) Water and organic matters	91·895	91·895
(2) Soluble salts in water—		
Alkaline salts	0·054	
Lime	0·250	0·430
Magnesia, chlorine	traces	
Sulphuric acid	0·126	
(3) Matters soluble in nitric acid—		
Alumina	0·405	
Peroxide of iron	0·470	2·030
Lime	1·155	
Magnesia	traces	
(4) Matters insoluble in water and nitric acid—		
Silica and traces of clay	5·575	5·575
Unknown matters	0·070	0·070
	100·000	100·000

If these figures are compared with those expressing the composition of wood in the healthy condition, it will be seen that there has been great changes. The woody mass had passed in large part into the peaty state, and was impregnated with a quantity of earthy matter much superior to the proportion of ashes generally existing in wood.

Other analyses, and notably analyses establishing the nature of the water extracted from the bottom of excavations where the stakes are found, have demonstrated that these waters exercised over the wood of the piles a destructive action. The destruction of timber, in certain non-running waters, is therefore a proved fact.

A deterioration, and one of the most rapid, is often observed in wood exposed to the action of waters charged with sulphate of lime and sheltered from the air, as happens in foundations. The organic matter transforms the sulphate into sulphur, which is burned by degrees and loses all solidity.

Let it be added that these changes are only produced in special cases. In others, on the other hand, the preservation of timber in water is an acknowledged fact. The condition, age, and time of felling of timber must greatly influence this preservation.

In Spain, for example, Phœnician piles have been found of undoubted authenticity, and a deterioration of the surface of these stakes has been proved, but only to a depth of about 30 mms. The axis was intact, and it has been recognised that these stakes were of cedar. The surface was of pure lignite, for, although the aspect was that of peat, analysis gave the same elements as for the lignite of Frankfort and Nassau. The change was not the same at all levels; stakes intact upon

the lower part were badly attacked upon the upper. This difference undoubtedly arose from the fact that different levels were not charged with the same proportion of ferrous salts, which are most dangerous for wood, especially when they contain the sulphate.

FOSSIL WOOD.

Mineralogical specimens are frequently met with, which, although presenting all the physical and chemical appearances of stone, are only fossilised wood. Trunks of trees met with in this condition, whilst preserving the fibrous texture, are mostly either carbonised or, better, siliceous.

One of the most remarkable examples of this alteration of timber was furnished at the Universal Exhibition of 1889 by admirable specimens of petrified wood of the Arizona Forest.

In the Apachia country, upon the territory of Arizona, 40 miles south-east of Olbrook (U.S.A.), a plain is found where formerly there was a virgin forest, but which is to-day changed into a vast heap of stones.

These trees, transformed into stone of a durability exceeding that of quartz, are half buried in the lava and ashes issuing from volcanic eruptions.

The trunks generally lie embedded upon these ashes and lava, which are covered with sand under a depth of about 35 ft.

Transformation is produced slowly, the silicate being substituted for the organic matter in such a manner that the slightest sinuosities, the grain of the wood, and the rings were preserved quite intact.

The colours of the trunks, which are of the most variegated and beautiful descriptions, have even appeared to surpass in beauty those of the most celebrated marble and the most renowned agates.

In several cases the preservation of the tree is perfect, including the bark and the heart with its regular rays.

Naturalists who have sought to determine to what varieties these fossil woods can belong have not been successful in their research, for most different opinions have been expressed.

Some declare in favour of the cedar, pine, and palm-tree ; others, the oak, nut, cotton-tree, etc.

This marvellous deposit covers a surface of about a thousand acres, and it is estimated that it contains a million trunks.

As to the manner in which this remarkable phenomenon is produced, it can only be supposed that the entire forest was roughly turned upside down and completely covered with ashes and lava. The warm waters

charged with silica spurting from springs or forced out by volcanic action pierce these ashes, refreshen them, and come in contact with the trees—hence conditions favourable to silicification.

It can also be thought that the change has been caused by the sojourn in the volcanic tufa. Very siliceous waters then penetrate slowly into the buried woods, gradually depositing their silica in the cells; the jasper and agate take the place of the cells and fibres.

The astounding variety of colours presented by these petrified woods causes the supposition that siliceous waters also contain metallic oxides. The geological layer containing these woods is the sand of *Chinarump*, a group of the tertiary period. The name *Chinarump* is the local Indian denomination of the point of arrows; it is thus that the Indians designate agatised wood, with which they usually make their arrows.

Upon the whole surface of the emplacement trees lie embedded and strewn in a variety of different positions; their dimensions being most variable. One sample, among others, of a length exceeding 160 ft., is found broken in sections of uniform size, as if sawn before the catastrophe.

Another tree has been found in a multiple of fragments. It can be supposed that these different fractures have been the result of alternatives of heat and cold acting upon the waters, which had even penetrated into the trees themselves.

It has already been said that these trees show themselves in different positions; some of them exceed 190 ft. in length, with trunks of about 10 ft. in diameter.

Upon a point of this antediluvian park, one can admire a natural bridge of agatised wood, formed by an immense tree lengthwise and crosswise, the two ends of which are twisted and buried in the sand. This wood, beautifully shaded, presents all the tints of the spectrum. The colour often appears in distinct places forming spots, or else, on the other hand, the tints are imperceptibly mixed, often also intermixed with white, black, or grey.

The broken sections of these trunks are often bordered on the interior by amethyst or calcite, differently shaded. With the microscope an even better view is obtained of the beauty of the colours, and it is proved that the structure of the smallest cells is found perfectly preserved. The structure of these cells shows that these trees have grown under a mild and equable climate. The walls of the cells are of almost constant thickness. In some specimens the microscope has detected the presence of destructive fungi.

PART V.

THE PRESERVATION OF TIMBER.

IN the whole of the preceding we have endeavoured to show how important is timber in general. We have seen what innumerable varieties of useful descriptions have been placed at our disposal by Nature, and have also aimed at making it understood how pressing it is, for all civilised nations, to succeed in *preserving* actual forests, whilst cultivating them with intelligence and prudence, as well as to seek to reconstitute in part those which, for long years, regrettable wasting had caused to disappear.

To sum up, we have, especially up to this point, sought to indicate the means of preserving growing wood—in a word, the forests. It now remains to show that it is not less interesting to endeavour to preserve woods once felled and cut up, and to maintain their durability as long as possible; this will be the subject of this part of our study.

CHAPTER XVII.

GENERALITIES—CAUSES AND PROGRESS OF DETERIORATION—HISTORY OF DIFFERENT PROPOSED PROCESSES.

LET it be at once said that this question of the preservation of wood, which must be placed in the front rank among the most important questions of public economy, has not yet been thoroughly solved. A log of wood should be able to resist time as long as a mummy; this, however, is not yet so.

One must not be frightened at the possibility of the disappearance of

wood over the surface of the globe, but it is, all the same, of great importance to prolong the durability of timber which has been worked and employed in buildings or in the arts.

The problem of the lengthy preservation of timber is capital for a great number of industries which make a considerable use of this raw material. This problem, formerly solved incompletely by the mere desiccation of timber and by protective coats destined to prevent air and dampness from penetrating into the pores, has given rise to numerous methods, all having for their basis the introduction of antiseptic liquids into the interior of the timber to be preserved.

But first let us see what are the causes of deterioration of the timber in use.

CAUSES AND PROGRESS OF DETERIORATION.

Wood exposed to the air does not take long to decompose; it becomes equally destroyed when under ground. It can even become altered when it is immersed in water. This deterioration arises from several causes.

At first the albumen and the nitrogenised matters which it contains tend to provoke there the development of different beings. Cryptogamic vegetals are formed there, and, moreover, in the air as well as in water, it is attacked by insects or xylophage animals. Besides, the wood is susceptible of experiencing fermentation, and it then undergoes slow decomposition, which is analogous to that of the animal matters. It can be said, in resuming, what has already been established, that the elements composing timber are the following:—

In the first place, the ligneous matter constituting the framework of the wood or the walls of the cells, and which is composed of carbon, oxygen, and hydrogen.

In the second, the incrustated organic matter clothing the membranes of the cells and showing itself in a layer more or less thick and irregular; this is also composed of carbon, oxygen, and hydrogen. It especially abounds in the centre, the density and durability of which it augments.

Lastly, dissolved in sappy water, fatty, sugared, and saline nitrogenised matters, in which nitrogen associates itself with the three other elements, and which fill the cavities of the woody tissue. These matters are more abundant in sapwood than in the heart of the wood, and in larger quantity in the young vegetable organisms than in those formed at an earlier period.

Timber can, as is seen, be considered as formed of two different matters: one, which predominates, of ternary composition; the other, which is much less abundant, of quaternary composition. Both are subject to spontaneous attractions.

The ternary matter finds its most essential cause of alteration in the great affinity of its carbon to oxygen, an affinity which is favoured by alternatives of dryness and dampness, and which has, for its final results, the conversion of timber into a greyish or brownish powder.

The quaternary matter is submitted not only to the affinity for oxygen of the carbon which is found contained therein, but also to the affinity of its nitrogen for hydrogen, and of these two affinities there results a force of perturbation which renders the decomposition of wood far more easy.

The nitrogenised matter presents besides conditions necessary for the nourishment of worms and the development of cryptogamic vegetals. These are two new and powerful reasons of the alteration of timber.

Timber therefore offers a double cause of decomposition, the gravest of which lies in the present changeableness of the nitrogenised matter.

Two kinds of means, one physical and the other chemical, have been proposed and employed under several forms to retard or prevent this decomposition, which demands a certain heat, added to the presence of water and air, to start it, and which ceases to take place when even one of these conditions is wanting.

HISTORICAL.

It was not until the eighteenth century that the scientific world busied itself with the causes of putrefaction, and sought, by experiment and analysis, to dive into the secret of it. Methodical investigations were undertaken of the phenomena of fermentation and putrefaction. They were at first attributed to the separation with the substance, by way of transformation of the unknown element, which at this period had received the name of "phlogiston." Then came the M'Bride theory, giving to carbonic acid the special power of maintaining the cohesion of the molecules. According to this theory, putrefaction commences when the molecules are disjointed as a consequence of the departure of the carbonic acid. None other of these theories explained why the cessation of the vital movement was the sole cause of the commencement of disorganisation of the tissues.

At the end of the eighteenth century the generally admitted opinion was that putrefaction is one of the forms of fermentation.

But this theory, as often happens, was preceded by practice, and several comprehensive lists of antiseptic compounds have been published since the end of the last century.

Towards 1850 the generally received opinion as to the causes of the putrefaction of wood was the natural consequence of the theory of fermentations created by Liebig. According to him, fermentation was nothing else but a sort of slow combustion, determined by the presence of certain organic matters in the process of decomposition.

This theory only demands, so that fermentation may take place, the co-operation of damp air. Mouldiness, parasites, or animalculæ signalled by the microscope in the substance in putrefaction are not the cause of phenomenon, but only its consequence; they come into being after the putrefaction has commenced.

Liebig's theory does not therefore explain the action of heat and cold, which retard or accelerate fermentation, neither that of chemical products, which equally modify it, of alkalies, which often accelerate it, or of acids, which generally slacken it.

Liebig professed the opinion that it is albumen which maintains life, of animals as well as of vegetables. When life disappears, albumen is decomposed and produces rot.

In admitting this theory, it is concluded that the substances fit for the preservation of timber were those producing the coagulation of albumen. Now, protochloride of mercury (corrosive sublimate), sulphate of copper, chloride of zinc, and oils of tar enjoy this property. The preservative action of these substances is therefore thus explained.

But what are the antiseptics capable of preserving wood? Does the coagulation of albumen sufficiently explain the action of oil of tar, and, in particular, that of creosote? A negative reply must perforce be given. It is certain that a number of substances which exert no preservative action over wood possess the property of coagulating albumen; boiling water is in this case. And this coagulation does not, moreover, suffice to completely preserve albumen.

Liebig attributed the production of rot to a slow combustion brought about by the presence of decomposing bodies, and, according to him, the phenomenon cannot be due to the action of germs or living organisms.

The generally-accepted theory of our time is entirely opposed to Liebig's assertions.

M. Pasteur affirmed that the phenomena of fermentation or putrefaction was only accomplished in presence and by the fact of living germs, which are thus the true agents of decomposition.

M. Tyndall discovered that the most easily putrescible substances, either animal or vegetable, can be indefinitely preserved in tubes where they are sheltered from germs. It does not suffice, for the preservation of those bodies, that they should be deprived of the germs once for all; it is also necessary to prevent the action of new myriads of germs, always ready to form.

This *savant* showed the germ penetrating through the opening of a tube as a trial, and, consequently, putrefaction declaring itself in the contents of the tube. A comparison can here be established with the orifice of a fissure produced in the wood—for example, under the action of the sun. The germ penetrates through the opening, and if this latter is prolonged in the mass of the wood, beyond layers which have been impregnated with antiseptics, it will carry the ferment of the rottenness in the middle of the piece of timber.

But if the antiseptic employed is a resinous or bituminous compound, it will flow into the fissure in proportion with its development, and will close the entry of it. If, indeed, a slit or wound produced in the trunk of a living fir-tree is examined, it will be seen that Nature has taken care to cover the wound with a resinous substance, which protects it against destructive agents.

Other facts support the germs theory, and prove that putrefaction is not produced in their absence; it is thus that bodies of gigantic mammoths have been preserved in blocks of ice throughout ages; trees of primitive forests have remained intact in a thick sheath of peat, and fragments of building timber thrust deeply under water have resisted rot for centuries.

In applying this theory one will naturally be induced to employ, so that protection may be durable, agents which themselves must be resistant or unchangeable.

The germ theory will then be able to give valuable indications as to the choice of these agents. It is therefore as well not to place much confidence in germinicides volatile or soluble in water. It is preferable to employ compounds capable on the one hand of destroying the germs, and on the other of preventing their contact with the timber to be preserved.

It is therefore necessary to exclude from the first those which may attack or impair the fibre of the wood, and amongst the latter may be ranged the liquids with acid or marked alkaline reaction, as well as certain metallic salts.

It will be seen that salts of zinc, mercury, and copper have been or are employed with certain success; among those, the sulphate of copper,

less soluble than chloride of zinc and less volatile than corrosive sublimate, should produce the best effects.

It can be concluded *a priori* from the preceding considerations that the best antiseptics would be the oily or bituminous substances which stop up the pores of the wood. One should choose out of these bodies those which, containing germinicide compounds, can become solidified most easily in the pores of the wood, and which require, in order to become volatilised, the highest temperature, and, in a word, those which are slightly or not at all soluble in water.

Whatever the variety of the timber may be, rottenness, whether dry or damp, makes rapid progress in the direction of the growth, whilst its progress is very slow and inconsiderable in the direction of the medullary rays. The top-end of logs are often rotten, whilst their periphery is still appreciably intact. Logs have often been seen completely split by rot by the prolongation of holes of pegs when the wood in juxtaposition is still perfectly healthy.

When the logs are not split, a trail more or less long of decomposition is observed in the common varieties. When the observation refers to oaks, the fibres which are found in the prolongation of the pegs are sometimes tinted black. The soluble iron compound borrowed from the peg meets in the oak enough tannin to colour it black. Very long trails are often seen offering but very feeble lateral deviation. The trail, blackened in the oak, rotted entirely or almost so in the other varieties, is not straight; it follows all the inflections of the woody fibres,—that is to say, it always travels in the prolongation of the first elongated vessels attacked.

All the wounds, kerfs of the saw, or blows of the axe, which occasion a solution of continuity in the elongated vessels, become causes of rapid rottenness.

It is to Jean of Verona, contemporary of Raphael, to whom the first idea of dyeing timber by impregnating it with different ingredients and boiled oils is attributed.

But before this time we find in the works of the ancients indications as to the means employed for preserving wood from rot. From the earliest historical times, man employed coatings of pitch or tar with this object. Ancient authors say that it was customary to preserve valuable wooden objects by applications of oils of olive, cedar, larch, and juniper.

Herodotus, and then Pliny, have written very lengthily upon the art of extracting and preparing oils, resins, and tars.

The perfection attained by the Egyptians in the preparation of their

mummies may also be called to mind; these processes of preservation, the efficacy of which has been proved after several thousand years, were undoubtedly of great value.

According to the examination which can be made of them at the present time, the bodies appear to have been impregnated with gums or odoriferous resins, or oils of cedar or bitumen, or perhaps also with marine salt. Herodotus and Diodorus Sicilus say that the bodies were first bathed in soda for more than two months, and then impregnated with oleaginous or bituminous preparations. But this simple preparation does not appear to explain the results obtained. It is generally believed that the corpses were previously exposed to high temperature in an oven, thus to eliminate the water from them and facilitate the ulterior preparations.

It is agreed that the organic matter of mummies did not become imputrefiable by the fact of a chemical modification of its substance, but simply by the presence of antiseptics.

But it may at once be said that a coating impermeable to dampness will probably never prevent the wood from rotting on the interior, if the fibre is damp and already attacked by mouldiness, and this crust under which the woody matter will have been mummified is only an imperfect preservative, for the slightest accident which removes a part of the protective covering will allow the enemy to penetrate even to the heart of the timber, and the evil will from that time be more grave because it will be invisible.

It is therefore evident that by impregnating the woody fibres themselves with a substance capable of removing the principal causes of alteration which threaten them, that one can, in a sure and efficacious manner, succeed in preserving the timber.

This truth, which to-day is incontestable, was recognised in the middle of the last century, for Reed (in 1740) and Hales (in 1756) proposed the immersion of the wood in a solution of tar so as to prolong the durability of it. Since 1719 Pallas had already advised the *mineralising* of the wood, in causing it to be macerated in a solution of sulphate of iron, then plunging it in lime-water to precipitate the salt and to form in the woody fibres an insoluble sulphate of lime.

Hales proved, by the action of the *suction* shown by the woody fibre, the penetrability by liquids by means of pressure.

After him, Duhamel discovered that coloured liquids penetrate the vegetable by *vital force*.

It may then be said that, from a scientific point of view, the problem relative to the penetration of liquids in the wood by the employment

of artificial force, the *injection by pressure*, has been solved by Hales' experiments, and that by the employment of *natural force, vital suction*, it has been solved by Duhamel's experiments.

Later, Carney, having observed in the rock-salt mines of Dieuze that joists of fir impregnated with salt had remained in perfect condition for more than twenty-five years, concluded from this the possibility of preserving wood by the injection of saline matters.

In 1810 Cadet Gassicourt gave himself up to a thorough study as to the action of vegetable or metallic colours; he proved that the curcuma gives to maple the appearance of a yellow satin wood, and that sulphate of cobalt gives to this same wood, by impregnating it, a very beautiful blue colour.

In 1812 Baron Champy, having been charged with the building of powder magazines placed below the level of soil, hit upon the idea of covering internally the walls of powder-magazines with lead sheets fixed over the wood, but it became indispensable to place this timber safe from rot.

To arrive at this, Champy plunged some green wood in a tallow bath at a temperature of 130°, the water of which, becoming vaporised by the heat, was replaced by the tallow, which was in this manner introduced into all the canals of the woody fibres. Success crowned this attempt, which the high price of tallow did not, however, admit of general adoption.

Following Champy's attempts, Kyan proposed the injection of the corrosive sublimate—an antiseptic agent at once killing all the insects pre-existing in the wood and preventing all ulterior attack; but this process was far too expensive to be used industrially; it had, moreover, been pointed out by Homberg more than a century previously.

The penetrating processes of to-day may be divided into three groups:

(1) The processes by immersion.

(2) The processes by pressure in closed vessels.

(3) The processes based upon the displacement of the sap, and only applicable to green or uncleft timber.

But before studying the details of these different processes, let us say a few words as to the purely physical means employed, namely, drying or desiccation and carbonisation.

CHAPTER XVIII.

DESICCATION—SUPERFICIAL CARBONISATION OF TIMBER.

DESICCATION.

THE desiccation of timber should be studied from two points of view: in the first place, from the point of view of advantages in its employment, and in the second, from the point of view of its preservation.

If we consider timber in its employment, either as combustible or as building timber, it will be seen to be of the highest importance to use it in the dry state.

Damp wood gives, equal weights being taken, far less heat than that which is dry, because water is evidently prejudicial to combustion, and requires a great quantity of heat to pass to a vaporous state.

The drier the timber, the more caloric an equal weight of it will evolve.

In a green wood and that which is gorged with sap, a notable portion of caloric employed to vaporise the humidity of the wood is thus dissipated in pure loss.

Hartig found that beech trunk wood, aged eighty years, freed from sap, perfectly dry, gave, when burned, a quantity of heat represented by 1557, whilst the same wood burned green only gave a quantity of heat represented by 1226, or a little more than two-thirds of the dry wood.

When the wood has been strongly dried and exposed to the air in ordinary circumstances, it takes about 5 per cent. of water during the first three days, and it continues to absorb it until it absorbs about 15 per cent. of it. It then becomes very hygrometrical, and loses or absorbs water according to the state of dryness or humidity of the air.

M. Violette having submitted the principal varieties of timber to desiccation at 150° C., found the following results:—

Nature of Timber.	Weight of Timber.		Loss per cent.
	Before Desiccation.	After Desiccation.	
Agaric willow	52·36	49·20	21·32
Ailanthus (varnish of Japan)	112·07	78·60	29·91
Alder	98·58	84·01	14·90
Apple-tree	169·85	147·00	13·99
Ash	155·70	129·20	17·39
Aspen	105·10	91·50	12·94
Barberry-tree	93·09	66·50	28·57
Birch	112·73	70·80	37·20
Black alder	125·13	108·00	13·69
Bladder-nut-tree	65·76	54·50	17·12
Boon	56·38	51·50	14·23
Box	82·00	71·70	12·56
Broom	73·99	63·00	14·85
Catalpa	68·63	51·70	24·67
Cherry-tree	188·63	121·00	35·85
Chestnut	61·48	40·20	34·61
Clematis	88·65	43·00	51·50
Common acacia	100·96	67·90	32·31
Cork	26·52	25·00	5·75
Cotton-tree	30·70	27·80	9·44
Cotton-tree	91·30	77·50	15·12
Currant-tree	90·83	68·70	24·36
Cytisus	66·80	47·20	29·33
Dog-berry-tree	164·41	90·50	43·80
Ebony	154·29	141·20	8·39
Eglantine	112·06	82·50	26·38
Elder	197·29	141·50	28·02
Elm	134·27	122·50	9·13
Furze	122·58	95·50	22·86
Hawthorn	167·40	111·50	27·88
Hazel-tree	106·78	75·60	29·20
Holly	181·35	113·00	37·69
Honeysuckle	87·01	51·40	14·93
Horse-chestnut-tree	116·16	62·20	46·45
Iron	94·62	81·60	13·76
Ivy	82·06	61·00	25·67
Juniper	110·33	67·30	39·00
Larch	132·33	95·50	27·83
Letter	91·17	77·50	15·00
Lignum vitæ	309·54	278·50	10·03
Lilac	94·42	60·60	35·82
Lime	127·94	70·00	45·31
Mahogany	115·25	98·00	8·80
Maple	122·68	94·00	22·72
Maritime pine	89·48	47·00	47·47
Medlar-tree	44·04	38·00	16·16
Oak	151·30	125·00	15·40
Palm-tree	92·05	79·50	13·63
Pear-tree	147·26	114·80	22·47
Plane	128·33	108·00	13·82
Plum-tree	250·50	182·00	27·34
Poplar (trunk)	47·11	25·70	45·45
Poplar (root)	34·94	22·00	37·00
Poplar (leaves)	24·20	10·50	56·61
Prickwood	86·89	56·00	35·55
Privet	44·19	37·50	15·15
Rush	14·67	13·00	11·39
Satinay	83·08	74·00	10·93
Service-tree	148·11	68·40	51·91
Snowball	117·93	95·20	19·27
Straw of corn	66·83	58·20	13·13
Sycamore	135·04	84·40	37·50
Sylvester pine	69·20	37·30	46·10

Nature of Timber.	Weight of Timber.		Loss per cent.
	Before Desiccation.	After Desiccation.	
Thuja	72·76	50·70	29·11
Vine	113·65	78·00	31·22
Wild cherry-tree	118·15	96·00	18·75
Wild quince-tree	104·54	70·00	33·04
Willow	95·91	81·50	15·03
Yew	194·14	175·20	9·75
Yoke-elm	125·21	104·50	16·54

The employment of dry timber presents so great an advantage that, in a large number of works, not only is the timber required to be as dry as it can become by desiccation in the air, but it is also dried in drying-stoves.

In the forges of Lippitzbach, upon the Lower Drave, in Carinthia, timber is dried by burning a part of this combustible in a special building, of which Fig. 151 represents a longitudinal cutting, and which is composed of a rectangular masonry chamber 8·50 m. by 5·50 m., having for upper wall a vault whose top rises to 4·40 m. above the soil.

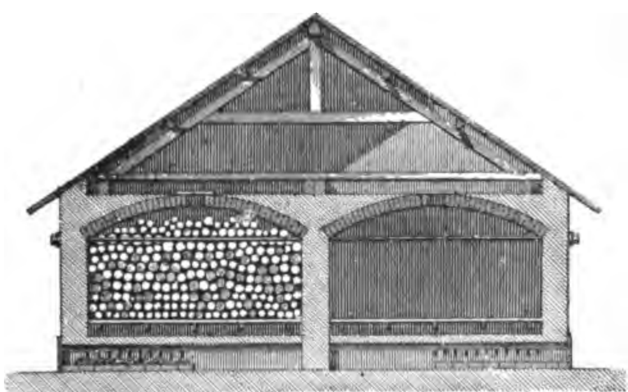


Fig. 151.

This chamber is divided into two storeys by a horizontal frame; the upper compartment receives the charge of wood to be dried. In the lower compartment the agent of this conversion is prepared, that is to say, a current of burnt gas carried at a moderate temperature, insufficient to promote carbonisation.

The frame forming the separation of the two compartments is composed merely of beams, fastened at their ends in the walls of the chamber, and of small mobile beams placed transversely upon the first, the separation of which is regulated according to the dimensions of logs of wood.

The wood is charged in the oven, partly by two lateral doors, the floor of which is level with the frame, and partly by three orifices made in the vault. To facilitate the circulation of the warm gases in the centre of the mass to be dried, more spaces are reserved there than there exists in the corded wood; thus, only 100 to 110 stères of wood are put in the oven in question, that is to say, about four-fifths of the space is filled. The proportion of available space filled, which is about 0·67 m. in corded wood, is therefore found reduced in this charge to 0·56 m.

Fire-grates, which partly constitute the lower compartment of the chamber, provide the current of warm gases necessary to the preparation of dry wood. They are each composed of a vaulted passage 0·50 m. broad, and 0·70 m. high, occupying in length the whole width of the chamber.

The combustible, which is partly composed of shavings and *débris* accruing from the splitting of the wood, is charged upon two ranges of bricks serving as andirons, upon a space of about 6½ ft., through a door of sheet-iron, underneath which there is constantly a strong current of air.

The excess flame and air are at first carried, over the sole, towards the posterior extremity of the grate; thence they come back inversely licking the vaulting, and they are usually found converted, by their mutual reaction, into burned gases when they return to the part of the grate contiguous to the door of the furnace. In this passage these gases yield at first a part of their heat to the walls of the grate by radiation; they become cold again by becoming intermingled with the affluent air entering through the interstices of the door before exiting by numerous side-holes in the lower compartment of the chamber. Here the temperature of the burnt gases undergoes considerable lowering, as a consequence of the radiation exercised over the mass in the higher chamber.

However, by reason of the high temperature which they preserve, these gases rise in the portion of the woody mass situated above the stoves of the grate, and contiguous to the wall of the chamber where the walls of the furnace are made. Thence the gases proceed, by way of the vault, towards the opposite wall of the chamber. More or less cooled by contact of the wood and by the absorption of water vapour, the gases afterwards come down along the wall, touch the ground of the lower compartment of the chamber under the levels of the side-holes of the grate, and at last pass outside through six orifices, having a hole of about 14 square decimetres, with a temperature gradually rising, as the operation advances, from 30° to 90° C.

The time necessary for the evaporation of a charge varies according to the hygrometric condition of the wood, and according to the temperature of the atmosphere. In summer the furnace may be kept up from two to three days; in winter for six days.

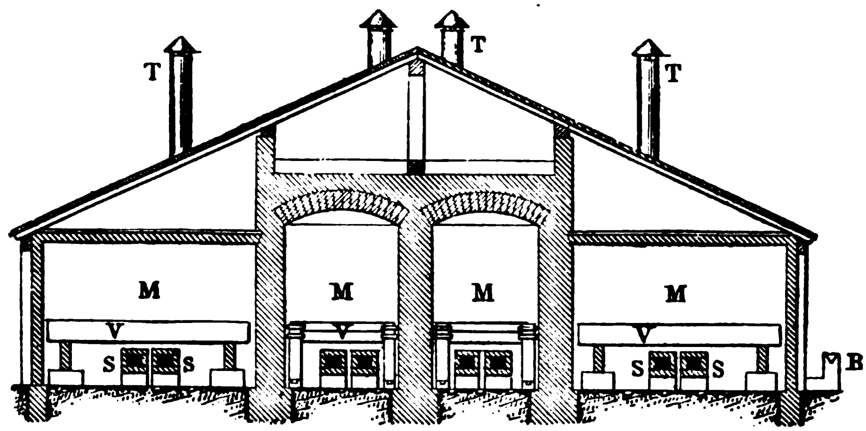


FIG. 152.

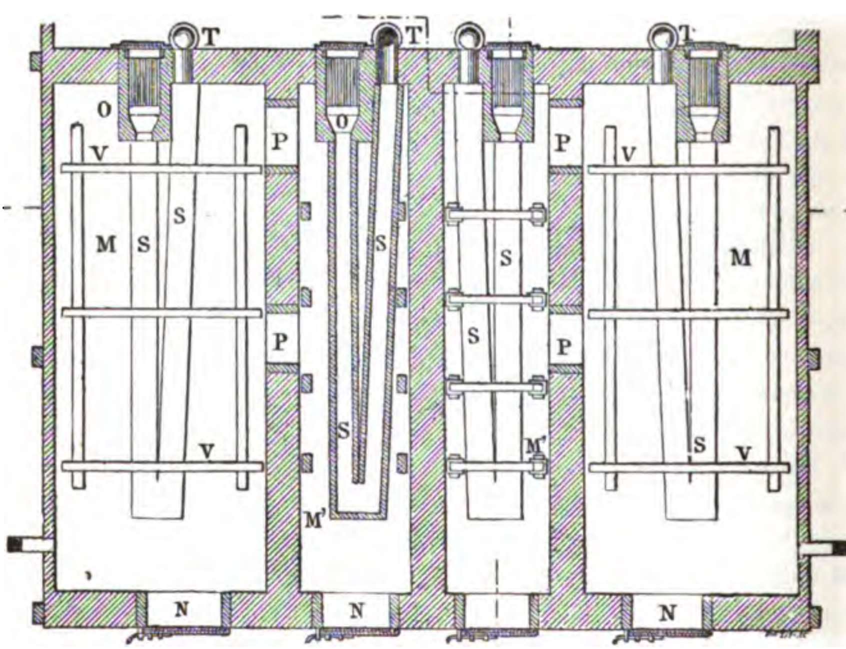


FIG. 153.

When it is seen, on the appearance of the gases, that they are no longer charged with water vapour, the heating is stopped, the lateral doors are opened, and the orifices made in the vault. The walls of the chamber are thus cooled, as well as the wood, and unloading is after-

wards proceeded with. The consumption of wood varies with the duration of the operation; on an average, it is estimated at 33 per cent. of the wood dried.

The temperature of the wood must not exceed 170° C.; higher than this it will ignite.

In order to lower at this point the temperature of the gases coming out of the grate, three different means are employed:

(1) Shavings containing often more than 50 per cent. of water are burned in the grate.

(2) A large excess of air can be admitted into the grate.

(3) The gases are made to stay in the empty space forming the inferior compartment, where they are cooled.

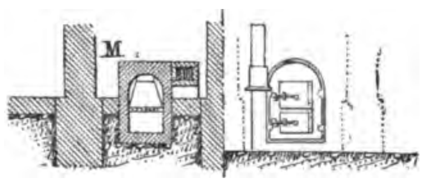


FIG. 154.

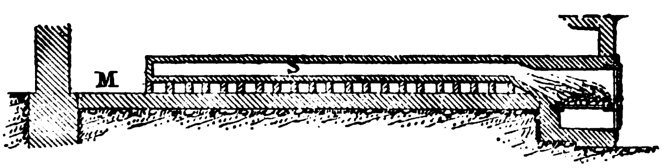


FIG. 155.

When it is a question of building wood or that used in joinery, dryness is also a desideratum; these different timbers need to be conveniently dried, so as to avoid the contraction which occurs in their fibres when they still preserve in their pores a certain quantity of sap.

To attain good desiccation, the timber may be carefully stoved, the arrangements for this varying according to the descriptions of wood submitted to desiccation.

At the Graffenstaden works the system of drying-stoves represented in Figs. 152, 153, 154, and 155 has been used for a long time, and has given excellent results.

Fig. 152 is a transverse section of the stove.

Fig. 153 is a general plan.

Figs. 154 and 155 are transverse and longitudinal sections.

The stoves and drying chambers are of trapezoidal form. The apparatus comprises six stoving chambers, like MM′ heated by seven grates and forming two blocks of buildings separated by a passage. The

figures only show one of the buildings containing four well-closed chambers, and which close iron doors N.

The upper part of these doors is of glass; through this the progress of desiccation of the wood can therefore easily be watched.

A special furnace O heats each chamber.

The chambers in the middle of M′M′ are smaller than the others MM, with which they communicate by doors PP.

Chimneys R allow the disengaged vapours to flow into the atmosphere.

The grates are prolonged by long horizontal vent-holes S, which end at chimneys T, which permits of the heat of the combustion products being very well utilised. Above these vent-holes, cross-pieces V are mounted, which receive the wood submitted to stoving and drying. This timber is conveyed to the oven on small waggons, then piled up on the cross-pieces.

The stay in the stove varies from ten to twenty days, according to dimensions.

The following are the temperatures at which one usually stops:—40° for oak and 50° for fir.

When it is a question of timber destined for special manufactures, like that of pianos, for example, special precautions must be taken, and these will be pointed out.

The wood employed in this manufacture is ordinarily—*oak*, which plays the principal part in the construction of the case; *fir*, which constitutes the *barrier* and gives resistance to the case; *beech* and *lime* also fill an important part, one for the making of the wrest-plank, the other for the keyboard; the pear and maple are employed for the pieces constituting the mechanism; and exotic wood serves as a decoration of the instrument.

The united tensions of the cords of a grand piano being able to rise to more than 13,000 kilogs., it will be conceived what resistance the case should present, which can only be partially consolidated by iron-work.

Consequently it is that which takes the largest consumption of wood; it is also that the most completely dried wood, since the preservation of the tensions of the cords, and consequently that of the harmonic qualities of the wood, depend upon the permanence of the form and dimensions of the case.

One must therefore, in piano-making, apply methodical desiccation processes, capable of assuring a timely supply of the wood necessary to the work. The succession of the operations is the following:—

Planks of oak, fir, and lime, which alone stand exposure to air, are piled up regularly, so as to assure circulation of the air, and left in the open for from one to four years, according to the thickness, with the sole precaution of covering each pile with a kind of deal roof.

At the end of this time the piles are taken down according to the order of their construction; and the timber is transported in large storey-sheds, open at their lateral surfaces, and arranged so as to permit of the constant circulation of air.

Planks of pear-trees, beech, and maple, and exotic timber are, on the other hand, placed immediately under these sheds.

After a sojourn varying from one to three years, according to thickness, and when the timber has thus undergone by the simple action of the air at the surrounding temperature, a first and slow desiccation, the wood is transported to special drying appliances, where desiccation is continued by the action of warm air.

These drying apparatuses are constituted by a large brick building, provided with a storey and divided by a longitudinal partition, in two long chambers, which only communicate through them at one of their ends.

In each of these chambers, at the end opposite to this communicating passage, a ventilating mouth working by exhaustion and a caloriferous one are installed. These mouths are arranged so as to produce at will, at each extremity, either a draught of air or an introduction of warm air.

Two different orifices are always opened in each of the two contiguous chambers—namely, the ventilator in one and the hot-air stove in the other, or *vice versâ*.

The warm air, thus introduced into one of the chambers, is therefore, in consequence of the disposition of the partitions, obliged to go through the whole length of this chamber to get to the communicating passage with the neighbouring chamber, then to again run through the latter before finding an issue at the other end.

The two contiguous chambers are therefore thus formed, as a matter of fact, as one and the same passage of double length, being traversed alternately, in one direction or the other, by a current of warm air.

The timber is piled up in the centre of each chamber in such a manner as to procure as much access as possible to the air upon its surfaces; the piles leave between them and the passages only small passages, and large sheet-iron panels forming doors with the chinks stopped up, permitting of closing so as to compel the warm air to traverse the piles of timber themselves.

The air thus travels from one chamber into the other, in becoming charged with the dampness which it carries away from the wood. Those

chambers nearest the air-holes are naturally dried, in this manner, far more quickly than those which are placed at the other end of the heating apparatus. If they are then replaced by new non-dried pieces, leaving the current of air flowing in the same direction, it will be seen that this current of air will carry the humidity which it receives from this wood over the piles already dried. But in then reversing the current, this inconvenience will be avoided.

The piles are moreover rehandled periodically to examine the condition of the wood, and these rehandlings are taken advantage of to reconstruct them in different ways, so as to allow space to be provided for the new arrivals which will best suit the regular carrying out of the operations.

The timber remains from three to six months in these drying apparatuses, the temperature of the air introduced varying from 25° to 30° C., according to season. The wood is thus brought to a state of perfect desiccation.

The wood thus dried is, upon coming out of the stove, preserved in closed magazines, where (classed according to variety and production) it is stocked until use.

One can also, when unforeseen circumstances demand it, employ a more rapid method of desiccation. In this special case the wood is, after the first cutting, placed in piles in special stoves, where they are submitted to the action of a current of warm and damp gas arising through the imperfect combustion of wood.

These stoves, generally two in number, are installed near furnaces in which combustion is effected, and each one is placed in communication by a special conduit with the corresponding grate. The doors of the furnaces are kept almost constantly closed, so as to avoid the flames projecting and to determine the true distillation of the wood, which serves to feed the grates.

Desiccation, therefore, in this place takes place by the direct action of the smoke of complex composition which accrues from the imperfect combustion of the wood; this smoke deposits on the pieces of wood foreign bodies, which colour them brown, at the same time carrying off with it the dampness which they contain.

The vapour which is formed, by softening the fibres of the wood, contributes towards facilitating the departure of the sap, and it is to this effect that this desiccation process owes the property it possesses of opposing the production of cracks which desiccation carried out in dry and warm air would infallibly provoke without that.

Wood submitted to this current of gas, the average temperature of

which is maintained between 35° and 40°, is dried rather quickly, the operation generally being finished at the end of less than two months.

An apparatus introduced into industrial practice under the name of *aero condenser* is show in Fig. 156, and appears to give good results in the mechanical drying of timber.

As is seen, the principal device is a screw ventilator, causing a strong current of air to pass over a group of vertical tubes which, on the interior, are traversed by a current of vapour. For that, the waste steam of the works is employed. It penetrates through the top into the tubular group, is condensed under the action of the current of air, warming it by abandoning its latent heat. At the bottom of the aero condenser the steam is condensed in the condition of distilled

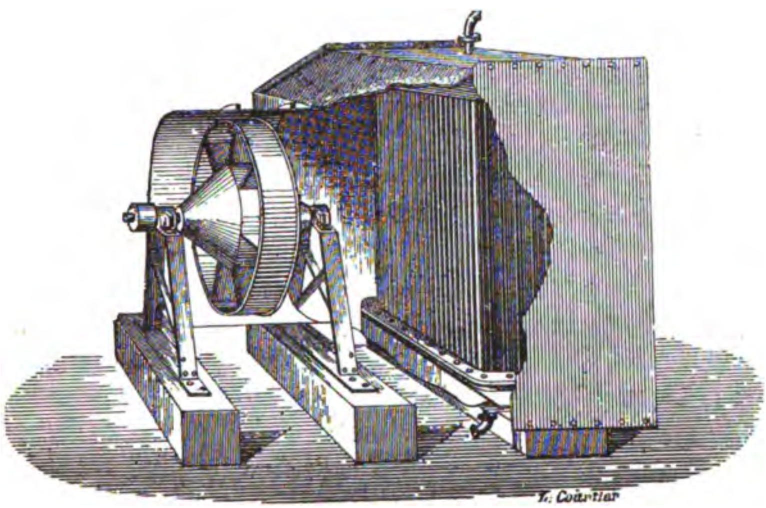


FIG. 156.

water. A powerful current of warm air therefore emanates from the apparatus, and this air is afterwards directed over driers, where it should be utilised.

If, now, it is desired to consider the desiccation of timber from the point of view of preservation pure and simple, it will be seen that it is, with plunging into the sand or water, the most ancient physical means of preservation employed.

This process has always been recommended from the earliest time for shipbuilding timber, though the results obtained were always very incomplete.

Artificial desiccation by fire or vapour was, at the beginning of the eighteenth century, employed in England and America for the preservation of shipbuilding timber, but did not give good results. This

process undoubtedly dries the timber more efficaciously in a few hours than would the exposing of it in the air for several months, but it often changes the quality of the timber. It makes it in all cases very hygrometrical, and highly liable to swell or crack. The stoving of certain ship timbers is, however, still done, but only when it is necessary to bend the wood.

It is not the same with carbonisation, which will now be dealt with, and which constitutes a good process of preservation.

CARBONISATION.

Since the earliest times it has been known that carbonisation is one of the best known means for the preservation of timber. The mode of preparation permits, moreover, of the preservation of certain woods which are with difficulty injectable.

To preserve the stakes or posts which are forced into the ground, the part which is to be buried is carbonised, and it has often been proved that this portion remains intact for a long time after the exterior portion has undergone the effects of putrefaction.

In the demolitions of the Flora Pavilion, at the Tuileries, foundations of carbonised stakes nearly three centuries old have been withdrawn which were well preserved.

At the Cherbourg Arsenal long and minute experiments have been made, as a result of which the Marine Administration has decided that the hulls of all wooden ships should be carbonised. Similar experiments have been carried out in England, and have given the same good results.

In general, the process of superficial carbonisation consists in flaming, with the aid of a gas blowpipe, the whole surface of the wood submitted to the operation.

Three principal effects are produced in this case:

(1) The surfaces which are still very damp are promptly dried in consequence of the almost instantaneous evaporation of the superficial hygroscopic water.

(2) The putrescible organic matters, as well as the microscopical organisms, animalculæ, and cryptogamic plants, experience torrefaction and even partial combustion, which destroys all vitality and every tendency to fermentation.

(3) The woody tissue itself, at this high temperature, to 2 or 3 tenths of a millimetre in depth, is partially distilled; it frees the ordinary products of the distillation of the wood, notably acetic acid,

creosote, different carbides of hydrogen—in a word, the tarry matters endowed with most energetic antiseptic properties.

Thus, with the same blow the ferments and putrid organic matters are destroyed, and the woody tissue is impregnated with tarry products—antiseptics competing energetically in its preservation.

Carbonisation is therefore a powerful means of preservation of certain timber. Never will be seen, upon wood covered with a carbonised layer, mouldiness or fungi develop themselves, which are always the forerunners of fermentation. The only difficulty is in applying this process to pieces or collections of worked wood, without altering the shape or volume of it. This difficulty has been successfully surmounted by M. de Lapparent.

The principle of the apparatus employed by this engineer lies in the use of the gas blowpipe.

This blowpipe is composed of a copper nozzle, formed of two pipes soldered together. By the large pipe the gas arrives, by means of a caoutchouc tube, which is connected with a gas supply. It is necessary that the orifice through which the gas goes out should be sufficient to feed thirty jets.

The small lateral pipe, which, at the end of the nozzle, penetrates into the large pipe, and comes out in the centre of the sphere forming the end of the nozzle, leads from the air furnished by pedal bellows, which the operator causes to work. The end of this lateral pipe is united to the orifice by which the air comes out of the bellows, by means of a caoutchouc tube. The large pipe is supplied with a cock, which is opened to allow the gas to arrive. The bellows are at once made to work, and the enflamed gas-jet reaches great intensity. It then suffices to bring the jet of the blowpipe over the wood which it is desired to carbonise. As soon as the timber is highly blackened, carbonisation is sufficient; the carbonised layer must not be more than half a millimetre thick.

It is not the pulverulent part which is at the surface which prevents rot. If the carbonised timber is rubbed with a brush, the charcoal powder disappears; a brownish surface remains, which alone prevents putrefaction.

It is seen that the result of this operation is, whilst carbonising the surface, to burn all the spores and to transform the exterior layer into a hard, black, horny matter, impregnated with creosote and tar, which prevents all vegetation.

This preservative action, produced by superficial carbonisation, has been verified in several ways. Pegs forced in the ground near some water and withdrawn after eighteen years, are found to be in such a good

condition that it is only with difficulty that the point of the knife will penetrate into it; whilst a year's stay in damp ground of a non-carbonised post is sufficient to determine on the surface a rot several millimetres deep.

A satisfactory proof of this was given more than a century ago, when it was desired to introduce the system of superficial carbonisation into English marine arsenals. The *Royal William* was partly prepared in this manner, and it has been proved that this was one of the vessels of the British Navy which had the longest existence. However, the practice of the carbonisation of ships was not then generalised, nor even maintained, for the means employed to apply it were then too costly, and there was too great danger of fire for it to be employed advantageously.

The means of preserving economically the harder and less changeable timber should evidently apply advantageously to carpenters' work, as to a crowd of other pieces of wood exposed to the destructive reactions favoured by more or less damp and warm air. Improved methods have always been sought of rendering the flaming of the wood more easy and economical, and the attempt has been made to replace lighting gas by another combustible. The problem has been solved by the aid of two distinct processes, based one on the employment of heavy oil of rectified tar, and the other upon the production of a long flame, by burning in quite special conditions dry pit-coal or even coke, which as a rule only develops radiant heat.

It is known that 1000 kilogs. of liquid coal tar, a by-product from the gasworks, free from ammoniacal water, produce on an average, by means of careful distillation, 30 kilogs. of benzine and 160 kilogs. of heavy oil, generally utilised in an incomplete manner. This oil is usually of minimum value, and the heat or light obtainable from it costs barely a quarter of that resulting from the use of ordinary gas. It is, however, difficult to burn this oil, which usually develops a fuliginous flame.

This difficulty can be overcome by constructing a lamp analogous to that of enamellers, but in which a plaited, cylindrical wick, supported horizontally by a metallic tube, is constantly fed with oil, by means of a large cotton wick, with free and parallel shoots, which surrounds it, and the two ends of which are immersed in the oil, maintained at 5 or 10 millimetres below the plaited wick. As soon as the latter, impregnated with oil, is lighted at the end merging from the lamp, the fuliginous flame which it begins to spread is soon completely burned by the aid of a current of forced air which a concentric tube brings to the cylindrical tube supporting the wick.

A blowpipe flame is obtained in this manner which is regulated at

will, and which is directed over the pieces of wood to be torrefied. The latter, when voluminous and heavy, can easily be maintained upon supports, directed and revolved in front of the flame jet, so as to regularly torrefy their surface; it is often sufficient—notably for stakes, posts, props, vine-props, etc.—to treat in this manner the whole portion which is to be beneath the surface of the ground, and a height of about 20 cms. above, in order to protect the part the water reaches by capillarity.

The combustion of the heavy oil in the lamp mentioned is easier and more regular when it is mixed with an equal volume of petroleum, from the rectification of the rough product of Pennsylvania, freed from light and too inflammable hydrocarburets.

The flaming process, applied to carved and figured joinery and carriage wood, is not objected to for painting; in this case it is sufficient to remove by energetic brushing the light pulverulent charcoal layer before painting these surfaces.

The second economical process already referred to is due to M. Hugon.

The apparatus of this inventor is composed—

(1) Of a furnace containing the combustible;

(2) Of a movable column carrying the furnace and serving to make it move vertically or horizontally, according to requirements, by means of a mobile chariot placed on a table;

(3) Of a platform carrying the furnace;

(4) Of a double-draught bellows fixed to the furnace by a caoutchouc pipe;

(5) Of a reservoir of water or liquid to be injected;

(6) Of cocks serving to regulate the quantity of water to inject into the furnace at each blast of wind;

(7) Of a wooden bench which supports the wood to be carbonised.

The method of working this apparatus is easy. It is commenced by filling with water the cavity through which the caoutchouc tube brings the air from the bellows. The water has for its object the protecting of the caoutchouc tube, which might get burned by the high temperature of the furnace. The stove is lighted with old wood, leaving the lower part of the front door open; when the wood is alight the lower door is closed; the bellows are luted with loam and set to work; the combustible is afterwards charged by the upper orifice and in small quantities until the furnace is full. The combustible being well alight, the door of the upper orifice is closed and the flame emanates from the curved tube placed in front of the furnace.

It is this flame, actuated constantly and regulated by the bellows, which is projected over the timber, and which operates the carbonisation of it in a rapid manner.

When the furnace is in progress, the injection of the water is regulated by means of cocks; this water, carried away by the air issuing from the bellows, is decomposed in contact with the incandescent combustible. The combustible gases arising from the decomposition, in combining with the oxygen of the air coming out of the furnace, unite with the flame produced by the combustible, and thus increase, in a rather marked manner, its carbonising action. When the flame gets feeble, the burnt combustible is replaced in small quantities.

This system of preserving timber, which for a long time has rendered good service, is far from being perfect. It is very defective for railway sleepers. These latter, indeed, when submitted to superficial carbonisation, sometimes crack even to the middle, on account of the great inequality of the temperature. It therefore results that roads constructed of these sleepers present grave defects. Dampness penetrates into the cracks, rapidly destroying the centre, which has not been carbonised. The carbonised surface of the traverses is without resistance; it is so thin that it promptly disappears in fixing the chairs.

Railway companies have gradually abandoned this process for the preparation of their sleepers. It will be seen further on what process is actually in use in this department of railway work.

CHAPTER XIX.

PROCESSES BY IMMERSION—GENERALITIES AS TO ANTISEPTICS EMPLOYED.

THE problem of the preservation of timber as we have stated it, requires at once the solution of two principal difficulties. First, it is a question of finding a chemical substance whose preservative, that is to say antiseptic, properties are completely efficacious; secondly, of ascertaining a practical and certain means of making it penetrate into the wood to be preserved.

The nitrogenised matters contained in wood are submitted to numerous causes of alteration. Under the influence of water, oxygen, and air favoured with a certain temperature, the woody matter can also give birth to ferments which, whilst developing at its expense, attack the cellulose and transform it into water and carbonic acid; these reactions, by forcing a portion of the elements of the wood to enter into new combinations, necessarily modify all its physical properties.

This transformation of the constituent parts of wood can be produced under different and well characterised aspects.

Sometimes the nascent carbonic acid produced in abundance by the slow combustion of the wood, favours the development of numerous kinds of fungi which, being nourished upon the elementary constituents of the wood, quickly produce its complete ruin; sometimes fermentation developed in the internal canals of the wood, and favoured by damp, destroys the fibres and causes ravages, the more dreaded as they are hidden and unexpected.

Whether the theory of the germs already dealt with be adopted or not, it is none the less true that the existence of the nitrogenised matter in the cells of the vegetable tissue is still for it a cause of ruin by attracting a crowd of xylophage insects, which it nourishes, and which in searching it in the cavities of the wood, perforate it in every direction, often destroying with incredible promptitude.

The fermentation of the nitrogenised matter contained in the wood is

the principal cause of its ruin; it must therefore be endeavoured to remove this nitrogenised matter from the wood, or to remove all the circumstances without which there is no possible fermentation, such as the presence of air and water or, at least, to act directly on the nitrogenised matter to make it enter into fixed combinations which are not liable to ferment.

One of the principal physical means—desiccation or carbonisation—has already been mentioned, whose object is the arriving at the realisation of the first desideratum.

The second means—immersion—may be a purely physical means or else a physical action accompanied by chemical reaction.

As for the third desideratum to be realised—the fixation of the nitrogenised matter in an insoluble and imputrescible combination — the employment of several substances has been attempted to arrive at this, amongst which may be cited—

Corrosive sublimate;

Chloride of zinc;

Sulphates of iron, copper, zinc, lime, magnesia, baryta, and alumina;

Borax and salts of soda; and

Arsenious acid, iron pyrolignite, and heavy coal oils.

IMMERSION PROCESSES.

The *immersion* of timber, when it has for its object only a simple physical action, may consist, for example, in plunging the pieces to be protected in a bed of sand.

The plunging of shipbuilding timber into sand, in order to avoid inclemencies of the temperature, was used in 1836 in several of the French military ports.

As for immersion in soft water, this *modus operandi* was in favour in England towards the end of the seventeenth century.

Immersion in sea-water naturally gave the best results.

In 1819 the Maritime Council ordered the plunging into sea-water of the pieces of wood intended for shipbuilding. Opinion was, however, divided, immersion certainly got rid of a part of the vegetable essences, replacing them by saline particles; but it is said that these latter, attracting afterwards the dampness of the atmosphere, provoked, rather than prevented, putrefaction.

Even now, however, ship timbers are often kept in stock in sea-water, or are buried in the damp sand of the littoral which preserves them from the attack of marine organisms.

John Griffith, in his *Shipbuilding Manual,* informs us that what was best known, forty years ago, for the preservation of the oak timbers was the immersing of them in fresh flowing water or in stagnant salt water for five to six months; then placing them in the air, sheltered against sun and rain, and leaving them there about the same time.

To continue, it would appear that the immersed wood only discharges itself very slowly of a portion of the soluble matters which it contains, and that it is only the exterior layers which are deprived of them. Immersion, in these conditions, would therefore have no other certain effect than that of keeping the wood safe from contact with the air.

A preferable method would be that which would consist in causing the desiccation of the felled timber to precede by partial immersion in water, in order to remove a part of their sap, which would replace the exhausted water by capillarity, for they would thus be rendered less subject to cracking and rottenness.

The chemical means which were only employed in the second place, for wood preservation, but which date to a rather remote period, consist in applications of different coatings, and, as already said, in the penetration of different antiseptic substances.

The various fatty or resinous coatings with which the surface of the wood is covered have as their object preventing contact of the air, which is the most active agent of destruction.

Pliny mentioned different oils applied to the surface of the wood to guarantee it against the action of air and dampness.

It has been known for a long time that tar is a rather good preservative coating for marine purposes, where it acts for covering the wood, thus guarding against the destructive action of water.

For the better preservation of marine timber, it was suggested at Dunkirk to give it a coating of warm gelatine, and to tan this gelatine by the application of a concentrated solution of tannin, which rendered it insoluble. This is the preparation to which fishing-nets and the sails and ropes of the navy are still subjected.

The different antiseptic substances which have been found for penetrating into the wood aim either at expelling, as completely as possible, the sappy essence, which is the principal cause of their alteration, and in taking its place, from preserving them from all decomposition; or of merely driving the aqueous portion of the sap from the wood, and, by combining with the nitrogenised matter thus concentrated, of forming with this fixed and insoluble compounds, in which the vegetable essences are no longer susceptible of being attacked by dampness and, con-

sequently, can no longer give place to fermentation—the first and essential condition of rot.

GENERALITIES AS TO THE ANTISEPTICS EMPLOYED.

The nature of the antiseptic substances employed and the means of causing them to penetrate through woody masses have varied greatly.

The principal matters successively used are metallic salts, then vegetable and mineral oils.

Amongst the metallic salts, those of mercury and zinc were largely employed in England; those of iron and copper were more specially made use of in France.

Corrosive sublimate, or protochloride of mercury, served for a long time in the preservation of anatomical subjects, as well as in the embalming of bodies, to which it gives great durability, when Kyan thought, in 1832, of applying it to the preservation of wood. This salt was at first employed, in the proportion of 1 of salt to 40 of water, in preserving timber destined for special and even naval constructions. All experiments were favourable to it, and in spite of the property which the mercury possesses of separating itself from most of these combinations, it would appear that this timber had no untoward influence over the health. Unfortunately, the price of corrosive sublimate being very high, it was attempted to preserve the railway sleepers by employing a much more dilute solution, and the process fell through.

The sulphate and chloride of zinc were afterwards applied upon a large scale, especially in England.

The chloride of zinc is a very powerful antiseptic, but it has the drawback of being very soluble in water. The duration that it can give to sleepers of fir properly prepared is estimated at about ten years. In this case it is necessary that it should be employed in the proportion of at least 1 of salt to 40 of water, and that the quantity of salt injected into the wood should be at least 2 kilogs. per cubic metre.

EMPLOYMENT OF SALTS OF IRON.

Sulphate of iron must usually be rejected. It decomposes upon becoming oxidised; a portion of the sulphuric acid is put in liberty and destroys the cohesion of the wood; it is, however, necessary to except the tanniferous varieties—the oak, for example—for then we are in presence of a preservation process which has given rather good results, and which is based upon the action of salts of iron.

M. Hatzfeld, indeed, after M. Boucherie, proposed the impregnation of timber by means of tannic acids, followed by an injection of pyrolignite of iron. The tannate of iron is therefore deposited by degrees in the cells, which then renders them assimilable to oak buried for many years, and become quite unalterable.

The liquid to be injected is a mixture in water of a tanniferous substance and of a salt of protoxyde of iron.

The tanniferous substance which it is most advantageous to employ is the chestnut extract; it is found in large quantities in commerce at the moderate price of 5d. per kilog.

The most convenient salt of iron is pyrolignite, which at the standard of 20° Bé., costs wholesale about 2½d. the litre.

The dry chestnut extract contains on an average 60 per cent. pure tannic acid. As for the pyrolignite at 20° Bé., it contains, per litre, 66 grms. of iron. Tannate of iron contains 13 per cent. of iron. By the aid of these figures the economy of the process can easily be recognised.

Employment of Chloride of Manganese.

This salt, a by-product in certain chemical works, had formerly very little value. To remove its excess of acid, it is neutralised with carbonate of lime, or with oxide of zinc. The double salt of manganese and of zinc, thus obtained, has very marked antiseptic properties. In this preservation process, which is based upon simple immersion, the pieces of timber are plunged vertically into the metallic solution, so that about a quarter of the piece is bathed by the liquid. The timber remains plunged for a period varying from twelve to thirty hours. The solution rises through the fibres, penetrating them solely by capillarity, whilst horizontal immersion does not produce good results. Timber thus prepared becomes incombustible, and changes of temperature no longer exercise any action over it.

Employment of Sulphate of Lime.

In this case the timber is previously dried in an oven in order to free it from the whole of its dampness and of a large part of the turpentine which it contains, when a resinous variety is treated. It is afterwards enclosed in cylinders of special form, in which a mixture of water, sulphuric acid, and lime is forced, under pressure, which penetrates into the pores of the wood. After this operation the wood is withdrawn from the cylinders, and, when dry, it is ready for use.

As a consequence of the action of sulphuric acid in excess upon the lime, soluble bisulphate of lime is formed, which easily penetrates into the interior of the wood. Upon contact with the atmospheric air, the bisulphate appears, later, to become transformed into sulphate very slightly soluble, which can then no longer be removed, even when the wood is submerged.

The treatment just pointed out diminishes the density of the timber treated.

This very economical process may constitute a good palliative against dry or damp rot of the wood.

Employment of Borax.

This process principally consists in the treatment of wood by a boiling solution of borax in water, which dissolves and easily carries away all substances susceptible of decomposing, without exercising any injurious action upon the woody fibre, which, on the other hand, becomes harder, impermeable to water, unattacked by worms, and almost incombustible.

The following is the *modus operandi*:—A saturated solution of borax in water, in sufficient quantity to cover the wood, is prepared in a wooden or iron receptacle. The temperature is afterwards raised by the aid of steam up to ebullition, and it is maintained at this point for several hours, according to the porosity and thickness of the wood. This operation is afterwards repeated in a fresh concentrated solution of borax in water, but the wood is steeped for only half the time of the first immersion.

The timber is afterwards withdrawn, and as soon as it is dry it can be employed.

Employment of Sulphate of Copper.

We will confine ourselves to giving here the chemical results to which the employment of this salt has led, without dealing with the apparatuses used, which will be described a little farther on.

Important studies have been made by M. Rottier upon results furnished by the injection of timber by means of sulphate of copper.

This author first established that the woody matter, impregnated with sulphate of copper, finishes by changing at the end of a longer or shorter period, which is easily explained by the disappearance of the small quantity of copper fixed upon the cellulose.

Shavings impregnated with sulphate of copper, then washed in pure

water and afterwards dried, have been buried in vegetable earth kept damp by periodical watering with rainwater; at the end of a certain time the quantity of the sulphate of copper diminishes, black spots are seen upon the shavings, and, finally, the wood rots.

The causes under whose influence salts of copper are cleared from the wood are three in number—

(1) The presence of iron;

(2) That of certain saline solutions;

(3) That of carbonic acid.

Experiments made upon the shavings prepared with solutions of sulphate of copper containing different quantities of sulphate of iron, have led to the following conclusions:—

(1) Sulphate of iron has a certain antiseptic power much more feeble than that of sulphate of copper.

(2) Wood prepared by the aid of solutions containing at the same time sulphate of iron and sulphate of copper are preserved under the ground for about the same time, unless the salts of iron are in considerable proportion.

(3) There is no reason to prefer, for the preparation of wood, chemically pure sulphate of copper to the commercial sulphate.

This last opinion appears to have been confirmed by the example of the wheel of the mines of St. Domingo. This wheel was found, when discovered, in a state of perfect preservation, although it had been immersed for fourteen centuries in water charged with sulphate of copper and sulphate of iron.

A certain number of salts exert an injurious action upon timber impregnated with sulphate of copper.

If shavings prepared, washed, and dried in a solution of chloride of calcium, carbonate of soda, or carbonate of potash are immersed, it will be observed that at the end of some time these solutions always contain a rather considerable quantity of sulphate of copper, the wood containing less and less of it.

This fact shows that the preparation by sulphate of copper is not to be advised for timber to be employed in marine construction.

The destruction of timber prepared with sulphate of copper may be explained in the same way, when it is buried under tunnels or in certain calcareous earths.

Like certain salts, solutions of carbonic acid carry off from the wood the sulphate of copper that has been used to preserve it. It is sufficient, to prove this, to treat the impregnated shavings with the gaseous water.

In order to increase the proportion of metal fixed by the woody fibre, recourse must be had to other salts. It is in this manner that the employment of acetate of copper permits of fixing twice as much metal. Heating the prepared wood equally increases the proportion of copper.

Certain organic bodies act, in regard to the salts of copper, like the mordants relatively to the colouring matters. Introduced into the woody fibre, they are fixed there, allowing it to absorb sometimes considerable quantities of copper; the bodies giving the most remarkable results are indigo and cutch.

The employment of cuproammoniacal salts permit of the easy introduction of a large quantity of copper into the wood.

In taking the impregnated shavings through different processes and in causing them to rot, it is proved that the durability of the wood is the greater as the quantity of copper is the more considerable.

Employment of Tar and its Derivatives.

Since the year 1756 attempts have been made in England and America with the object of injecting or impregnating timber with vegetable tars or oils extracted from these tars.

In 1836 Moll proposed saturating the timber in closed vessels, first with the vapour of coal-tar oils, and afterwards with these same oils liquid and warm.

But the first really practical employment of tar was realised by the Bethel apparatus, which will shortly be spoken of. To-day, when timber is prepared by the aid of heavy oils obtained by distillation of tar, it is said that the wood is submitted to creosote treatment. As a matter of fact, the product called *creosote* comes from the tar of wood, for the phenol oils of coal tar contain none of the elements of the true creosote. Their most important component, from a scientific point of view, is phenol or phenol acid (carbolic acid), the creosote of which contains ether derivatives. In ordinary language, phenol acid or phenol is confused with creosote. Thence is it that the denomination "creosotised" wood comes, which is applied to wood treated by phenol and its homologue extracts from pit-coal tar.

For complete understanding of these processes of preservation, which are so important, it will be useful to give some details as to oils or products extracted from tar.

Coal carbonised in a retort engenders the following products:—Gas for lighting, ammoniacal water, tar, and coke.

Tar contains all the antiseptic substances of the coal. They can be

extracted from it by distillation. For that purpose the tar is heated in a large cast-iron retort, and the distillation is facilitated by a stream of vapour or by an imperfect vacuum. The components of tar are separated according to the order of their volatility, which is also that of their density; this latter increases with the temperature.

This distillation produces light oils not so heavy as water, heavy oils denser than water, and lastly a solid residue, which is rosin.

Light oils have no interest for our subject; they are those which furnish trade with carbides, benzine, toluene, etc., from which are derived, by the intermediary of the amido compounds, the whole series of magnificent colouring matters known under the denomination of aniline colours.

Heavy oils are, as already said, usually designated by the name *creosote*. They thus constitute a complex product, containing numerous substances whose physical and chemical properties are quite different.

In the first applications the crude creosote was employed.

It has since been recognised that there was great advantage in separating the active principles from it, which can easily be realised.

For some years commercial consumption demands more and more the fluid and light creosotes. These latter are easier to inject, and leave the wood more fit, whiter, and not so dirty after the operation, especially during winter. The remarkable antiseptic power which recent research has recognised in phenic acid has greatly contributed towards confirming this opinion.

Phenic acid, discovered in 1834 in coal tar, has rapidly acquired one of the most important places among the antiseptic agents used in medicine and surgery. This acid is one of the constituents of coal tar, and certainly one of the most useful. The efficacy of oils of tar can be measured by the quantity of phenic acid which they contain.

These are, as a rule, the lightest portions of the heavy oil—that is to say, those distilling between 183° and 254° C.—which should be preferred. Fractions containing naphthaline and paranaphthaline, which pass at higher temperatures, would not, therefore, appear to have the same value, from the wood-preservation point of view. The proportion of phenic acid varies in oils of tar, from ½ to 6 per cent., and even beyond.

In the employment of creosote certain English companies require for their sleepers that the creosote should be of a density bordering upon 1·05, oscillating between the extreme limits 1·045 and 1·055; it should not leave at a temperature of 4° any deposit of naphthaline or paranaphthaline; it should contain at least 5 per cent. of phenic acid, or some other homologous acid. Finally, 90 per cent. of the oil should

have distilled over at a temperature under. 333°. It often happens that the proportion of phenic acid required rises to 10 per cent.

However, the researches of several chemists have appeared to give results contrary to the opinion which has just been formulated.

To give an instance, M. Coisne experimented upon specimens of creosote from England, Scotland, Belgium, and France, containing 15, 8, and 7 per cent. respectively of phenic acid. A fifth sample, of very high density, not containing a trace of phenic acid, gave in practice the best results.

Each sample was divided into three parts. Wood-shavings were treated—

(1) With crude creosote;

(2) With creosote with an addition of phenic acid;

(3) With creosote, and a certain proportion of very heavy oils added, distilling above 330°;

(4) With each of the three portions obtained by fractional distillation of the creosote—light, intermediary, and heavy oils.

Shavings impregnated with the different products were steeped for four years in a special retting vat.

All the results, without exception, were in favour of heavy oils, and adverse to phenic acid.

These experiments therefore seem in complete contradiction to the theory attributing to phenic acid a preponderating *rôle* in wood preservation.

The reason of this apparent anomaly will now be adduced. It is known that phenic acid is volatile at the ordinary temperature; soluble in water, the combinations which it forms are slightly stable. A powerful germicide, it preserves fermentable substances as long as it is found therein contained in sufficient quantities.

But it is at once seen that phenic acid, one of the most powerful antiseptic agents, becomes, so to speak, absolutely inefficacious when found either in presence of water, which carries it off, or exposed to heat, which volatilises it. It cannot, therefore, be a useful agent in the preservation of timber which will be exposed to these two causes of alteration—damp and variation of temperature. This is the case with railway sleepers. Certain of these creosote-prepared traverses have been examined after long years of usage; phenic acid has not been found, though, on the other hand, naphthaline existed in considerable quantity.

It is therefore correct to conclude that, from the point of view of the preservation of timber, the preservative action of creosote is far more attributable to bases and alkaloids than to phenic acid.

The principal compounds contained in creosote of pit-coal tar are the following, in order of their volatility:—

	Specific Gravity.
Benzene	0·880
Toluenes	0·872
Xylenes	0·865
Cumenes	0·870
Pyridine	0·980
Phenol	1·065
Cresol	1·050
Naphthaline	1·153
Quinoline	1·081

In heavy oils it is phenic and cresylic acids (phenol and cresol) which are the most volatile and, at the same time, the most soluble in water at the ordinary temperature; they distil at the same time as the lightest oils. Afterwards comes naphthaline, which is insoluble in cold water and very slightly so in boiling. It is naphthaline which forms the principal constituent of the black sediment frequently presenting itself at the ends of pieces of creosotised timber. Naphthaline is sublimated under the action of heat, and is concreted in beautiful flakes of magnificent white.

If, now, phenic acid and naphthaline are separately exposed to ordinary temperature in the air, it is noticed that the naphthaline disappears less quickly than the phenic acid.

The same phenomena is observed in timber injected with one or other of these two substances.

Light oils which contain more phenic acid are evaporated with more rapidity than the heavy oils containing more naphthaline.

Finally, if repeated washings with cold water are practised, all the phenic acid can be carried off. It is thus seen of what importance the choice of injection oils is when it is a question of preserving wood under water.

Antiseptic properties are to-day recognised in naphthaline which are less pronounced than those of phenic acid, but more durable.

After naphthaline, the alkaloids of quinoline and leucoline distil over, then paranaphthaline or anthracene, and finally acridine, which is an antiseptic and energetic germicide, and, lastly, phenanthrene, carbazol, pyrene, chrysene, and benzerythrene. All these bodies, volatilising at high temperatures, may be of high value in wood preservation.

To sum up, the results obtained in practice seem to be justified, and we recommend the injection of timber with a mixture of heavy and light oils, and the use of the heaviest portions.

Excellent results have also been obtained by the use of *paraffine* for wood injection. Paraffine has energetic antiseptic properties; it is found in the heavy oils of petrole, schist, and bituminous tars. The employment of this substance has been especially praised for preserving wooden vats, which are employed in *artificial alizarine* works. It is known that this dye-stuff is prepared by means of *anthracene*, which, dissolved in acetic and chromic acids, gives *anthraquinone*. This, by a series of reactions, is converted into alizarine. All these reactions are carried out in a hot jet of steam. Now, the wooden vats employed are destroyed at the end of a few weeks by the acids and alkalies which are used. If, on the other hand, paraffine-injected timber is employed, the vats can be preserved for two years.

The paraffine preparation is made by simple maceration by means of a solution of paraffine in petrole, ether, or sulphuretted carbon.

The timber is first perfectly dried in a stove for about three weeks, then impregnated with paraffine, and finally covered with a siccative-oil varnish or silicate of soda. This latter has the advantage of being incombustible; if the timber is afterwards washed with hydrochloric acid, chloride of sodium and silica are formed, which stop up the pores of the wood.

Before describing the different apparatuses employed for injecting timber with any one of the substances whose effects have been studied, the conclusions arrived at by M. Melsens may briefly be mentioned, as a result of important studies made by him as to the employment of tar in the industrial problem of wood preservation.

(1) It may be granted that the common varieties—birch, beech, yoke-elm, etc.—well injected, can be substituted for oak in the making of railway sleepers.

(2) All the fixed substances, insoluble in water, unchangeable on exposure to air and dampness, fusible at a temperature not exceeding that at which timber deteriorates, such as tars, bitumens, waxes, fixed oils, colophony, etc., or their admixture, are most convenient.

(3) When a log is injected by alternating the effects of heat and cold, it can be completely or partially penetrated by preserving substances It is always convenient to finish by solid substances at the ordinary temperature, so that they can stop up all the pores most exposed to air and dampness.

(4) When the injection is partial, which is sometimes sufficient, it is absolutely necessary not to cut the log after injection, that is to say, it must already be shaped ready for use.

(5) When injection is only partial, it is always done in the same direction,—in a word, it follows the course the rot would take, so that when this commences it must first go through the injected and preserved portions before arriving at the wood it could affect.

(6) Injection can be obtained in a very simple manner by employing heat as solvent of the preservative matters, then by using as mechanical force the condensation of steam produced at a high temperature.

(7) When the logs are carbonised so as to preserve them, it is still essential—and especially in this case—that they should have received their definite form. By carbonising in tarry or analogous matters, the pores of the wood are stopped up, whilst carbonisation pure and simple may leave the interior of the logs accessible to air and damp.

(8) Sleepers or ordinary railway logs have no value when not in actual use, whilst those injected by tar may be utilised as firewood.

(9) A great advantage of injection by tarry matters consists in the employment which can be made of unbarked timber, as also that which is squared, green, or which has undergone any preparation.

Progress of Tar when it penetrates into Wood.

This author also made some interesting observations as to the progress of tar when it penetrates into wood. Experiments have been made on small blocks of different varieties (poplar, beech, fir, and yoke-elm) of 0·25 m. long by 5 cms. thick. They have been split after having been submitted to a more or less complete preparation. It has been proved, in some cases, that the tar which penetrates the woody mass follows exactly the contours and sinuosities of the longitudinal fibres, which it fills almost completely in some blocks, whilst in others, which have only received incomplete though sufficient penetration in many cases, the tar accumulates at all the transverse sections, thus stopping up the passages which give access to the agents of deterioration.

In larger blocks of beech and white wood, broad striæ have been noticed in which the tar has not penetrated, and, however, after all the circumstances of deterioration to which these blocks have been exposed, the wood has been found perfectly healthy at very little depth.

Progress of Damp Gases in Oak.

The wood of the oak, though not the sapwood, assumes, under the influence of ammoniacal gas, and rather quickly, an intense coloration.

From this point of view the following experiment is very curious:—A name is written in large characters upon the surface of the oak, using, to trace the letters, a thick varnish of colophony and essence of turpentine, applied warm. The side of the wood which has been written upon is afterwards placed upon a vessel, at the bottom of which there is some ammoniacal liquid, and which is almost hermetically stopped up by the wood. The ammoniacal gas acts upon the whole portion of the wood surrounding the letters, penetrating and colouring it, but it enters at several centimetres from the bottom upwards, whilst it only makes a very short course from right to left.

By acting in this manner, the letters, which are reserved by the varnish, appear white. By successively removing layers, the name will be found written in white on the interior of the wood, for the action of the ammonia has coloured all the fibres surrounding the letters. When, on the other hand, the whole portion of the wood surrounding the letters is reserved by varnish, the name will be found written in black or dark brown.

This curious property of ammonia can be made useful in giving oak an appearance of age and imitating antique furniture.

This coloration, produced by ammonia, can serve to show what the principal necessary conditions are for keeping a log of wood in a good state of preservation, when it has been submitted to processes of injection which do not fill the voids of the wood in a complete manner and throughout its extent. It is, indeed, noticed that this coloration—the result of the action of ammoniacal gas and damp air—is always produced in the same way as the deteriorations observed in deteriorated railway sleepers. This experiment therefore permits of easily determining the portions of logs which it is of the greatest interest to protect, namely, the pores, which allow air and damp to penetrate.

In building materials, it is proved that tar, and, better still, resin or stearic acid, can be substituted for water in plaster, and that this substitution, though the result of a purely physical action, is so intimate that solvents, such as ether and benzine, only dissolve a small part of the resin in the plaster.

Varieties with which Tar-Injection succeeds best.

This process does not succeed equally well with all varieties. As a rule, the following is what is observed in employing indifferently blocks of unbarked, squared, green, and dried timber, and even that in course of deterioration.

The alder, birch, yoke-elm, beech, and willow are impregnated easily and perfectly; fir sometimes resists complete impregnation, the layers of the centre of the tree remaining white; the aspen and oak offer very great resistance to impregnation.

It often happens with oak that the sapwood or the last layers are completely injected, whilst in other layers the tar has only penetrated a few millimetres. However, some of the blocks which were slightly penetrated absorbed water only with the greatest difficulty, and then absorbed but little.

Some portions, sometimes considerable, of wood resist injection, and their deterioration is arrested in consequence of the solid tarry coating, which stops up the pores over a certain length, and protects the woody fibres to which they give access.

Quantities of Tar absorbed by Wood.

According to the variety and perfection of the result, woods completely and perfectly protected with tar have absorbed from 30 to 50 per cent. of their weight (tar taken in the dry state, such as is obtained in drying it in the vacuum at 140°).

Usually in practice such high proportions need not be attained.

Experiments made upon numerous specimens of different varieties (oak, fir, beech, yoke-elm, and poplar), about 0·30 m. long by 7 cms. broad and 5 cms. high, have shown that even slightly deep injections, but with warm tar, could act efficaciously.

During these experiments the time of immersion in the preservative baths varied from five to fifteen minutes; the matters employed consisted of ordinary gas tar, that freed from the most volatile products, resin, oil; sometimes colophony was added to these matters. Upon coming out of the warm bath, the blocks were plunged in liquid and cold tar; generally, to finish them, they were heated for some instants in the warm bath with a view of drying them.

As to the different varieties, the average of absorption and loss is put in the following order:—It is the oak which absorbs and loses the least, followed afterwards by the fir, then the beech and white wood, which vary rather frequently, and, lastly, the yoke-elm.

One can inject with tar, in all or in part, blocks of unbarked, dry, damp, squared, and worked wood, having been prepared by salts, and even in course of rotting, by employing the condensation of steam and atmospheric pressure as mechanical force, and utilising the heat as dissolving force or liquefying the preservative matters.

Woods can be either completely or partially impregnated, and in both cases they resist more or less agents which alter them.

The preservative matter which is injected always follows the course taken by deterioration in wood which is altered spontaneously.

Superficial carbonisation is more efficacious when it is done by the agency of tarry matters than when the wood is submitted to a temperature which disorganises a part of it.

When a not very deep injection is produced, it is indispensable that the wood should receive, before the preservative preparation, the complete form under which it must be utilised.

A log completely saturated with tar or resin should have a very long existence if it were only submitted to ordinary chemical agents, but there is reason to take into account the mechanical causes of alteration.

Employment of a Combination of Soda and Creosote.

It has been seen that metallic salts, in spite of certain essential qualities possessed by several of them, must generally give preference to tarry oils unduly designated in commerce under the generic name of creosote.

The use of these latter is, however, rather embarrassing, and requires somewhat complicated appliances. Now, as has been seen, tarry oils contain a maximum of 10 per cent. creosote or carbolic or phenic acid.

When it is this latter acid which it is desired to utilise, it is evident that the excess of inert oil is useless.

Independently of this uselessness, the oil presents the grave inconvenience of rendering the absorption of the creosote by the wood more difficult.

The penetration of a liquid into a solid body depends especially upon the facility with which the latter can be moistened by the liquid. It is also known that a woody surface, impregnated with water, would not absorb any oil. It is difficult to dry the timber completely, and, moreover, when exposed dry to the action of the atmosphere, it absorbs the dampness of it.

As employed for works and railway stakes, it cannot be considered as absolutely dry, and, on account of the dampness contained in its pores, it resists the absorption of tar oils in a marked manner.

It cannot be made to absorb the oil by operating in a vacuum; the impregnation will be incomplete.

By applying, on the other hand, a creosote solution to wood, it would

not be exposed to the inconvenience of the presence of oil, and penetration would be obtained more easily and economically.

The employment of this system has been tried in Germany by means of a combination of soda and creosote containing 40 per cent. of the latter. The pieces desired to be impregnated are coated with this liquid, diluted with water or placed in cases and covered by the liquor.

The temperature is raised to 100° by means of a current of vapour, and then allowed to cool slowly. A layer of sulphate of iron is afterwards given, which saturates the soda, puts in liberty the creosote in the pores of the wood, causing the protoxide of iron to be deposited there. This latter appears to afterwards absorb the oxygen of the air still contained in the woods and becomes the sesquioxide. The cloth of sails and ropes are often prepared in the same manner.

CHAPTER XX.

INJECTION PROCESSES IN CLOSED VESSELS.

THE employment of a vacuum and atmospheric pressure in a closed vessel was conceived by Samuel Bentham as far back as 1794, who witnessed, during his residence in Russia, the difficulties which the air lodged between the fibres of the wood opposed to the penetration of all sorts of fluids.

He undertook, at this time, a series of experiments in order to ascertain if a pneumatic pump could be efficaciously employed to dislodge the air before introducing the liquid intended to preserve the wood. He placed the piece to be treated in a closed vessel, where the vacuum was made by a pump. He afterwards put the vessel in communication with the tank which contained the liquid to be injected, and the latter, under the action of atmospheric pressure, was carried into the vessel and injected into the pores of the wood, then entirely deprived of air.

The satisfactory results to which these experiments led caused Samuel Bentham to take out a patent in 1795, but special circumstances prevented his pursuing the application of his discovery.

THE BRÉANT APPARATUS.

In 1831 Bréant, Director of the Mint (of France), proposed the introduction into wood of metallic solutions by means of strong pressure.

His apparatus was composed of a cast-iron cylinder M, a forcing-pump P, and condenser N (Fig. 157), into which either steam or cold water can be brought through tube *a*.

The operation is conducted in the following manner:—The lid being removed, the piece of wood is introduced in cylinder M, and the liquid is introduced so as not quite to reach the top of the piece of wood. After the cylinder has been closed, the vacuum is made in N, by the alternative introduction of steam and cold water. The cock *b* is opened; the air passes partly from the cylinder into the condenser, and this

operation is recommenced until the pressure in the cylinder is below 0·15 m. This condition is maintained for some minutes, so as to allow the gases to leave the timber. The cock *b* is afterwards closed, and the liquid is introduced into the cylinder by means of the forcing-pump P until the pressure reaches 10 atmospheres. This pressure is maintained for a variable time, according to the nature of the wood and liquid employed. Six hours is usually a sufficient period. At the end of this time, the air is allowed to re-enter by degrees, and the liquid flows through cock *c*.

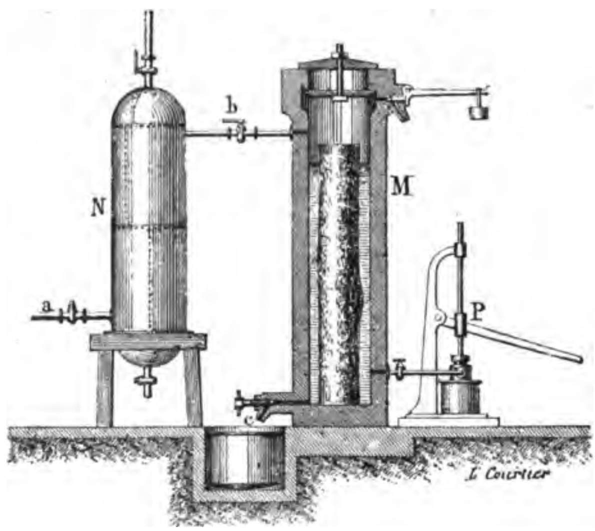


FIG. 157.

THE BETHEL PROCESS.

In 1838 Bethel modified the Bréant process. The matter employed by him was a mixture of bituminous oil and naphthaline, this latter possessing, as already seen, very powerful antiseptic properties. Its action can be explained in the following manner:—If a piece of timber is plunged into a product of distilled coal tar, the naphthaline coagulates the albumen of the wood, thus precluding putrefaction of it, and the bituminous oil, penetrating into all the capillary tubes, hermetically encases the woody fibres and closes all the pores, which are thus protected from air and dampness. This bituminous oil being insoluble in water and without action upon atmospheric air, permits of the application of the process in all possible situations. The apparatus employed by Bethel was the following:—

The wood to be preserved is first introduced into a sheet-iron cylinder

entirely impenetrable to air, and, moreover, rather resistant to support strong pressure. As it must be able to contain timber of large dimensions, it is made 6½ ft. wide by 65 ft. long. By the aid of a pneumatic pump worked by a steam-engine the vacuum is made, or, rather, the air therein is rarefied, until there is no more than a pressure of 9 cms. of mercury. The water and air contained in the cells of the wood can then be easily evolved. The heavy oil designated under the name creosote is afterwards introduced, whose average density is slightly higher than that of water. This oil is driven back into the cylinder by means of an hydraulic press, and then submitted to a pressure of 8 atmospheres.

The timber is allowed to stay in the cylinder a rather long time, so as to become impregnated with oil. A duration of twelve hours is usually sufficient, but it should be longer in proportion as the wood is more compact, denser, and more damp.

When the wood is still green, it is preferable not to employ it, for one will not succeed in impregnating it properly, even by increasing the pressure and greatly prolonging the experiment.

If the wood is compact, like oak, the heart cannot be treated very well; but it suffices, for its preservation, that the oil should penetrate into a zone some centimetres below the surface.

It is necessary that each cubic metre of wood should be impregnated by at least 115 kilogs. of heavy oil of tar. If the wood is to stop in the water, and especially in sea-water, 160 kilogs. at least are necessary for it. It is also understood that the proportion of oil of tar absorbed will greatly vary with the nature of the wood. It is greatest in the case of beech. It then rises to 325 kilogs.; it is also in this variety that the oil is distributed in the most uniform manner.

To make sure that the wood has absorbed the quantities of heavy oil necessary for its preservation, its weight is determined at the entering and coming out of the cylinder; that which has not gained sufficiently in weight is passed in again.

An ingenious arrangement permits of greatly reducing the expense of hand labour, necessitated by the charging and discharging of the pieces of wood in the cylinder; it consists in placing these pieces upon a small carriage which rolls on wheels, entering the cylinder at one end and coming out at the other.

When the timber has been submitted to this preparation, it assumes a deep brown tint, and experience shows that it resists putrefaction well.

Soft and porous timber is easily impregnated by heavy tar oil, and can therefore be utilised in buildings to replace hard wood.

The net price of creosotised wood is rather variable, for it depends

upon the price of the raw material, tar oil. Sixteen shillings and eightpence per cubic metre may be estimated as the average price.

Generally, timber that has been treated by this process is well preserved. It is not, however, protected from the ravages of the *Limnoria terebrans* when injection is not absolutely complete.

For telegraph posts and railway sleepers this timber gives very satisfactory results. It has been proved that it is not attacked by white ant. In mines and quarries it resists brown rust and damp.

It is particularly in sea-water that creosotised timber gives the most remarkable results. Comparative attempts have shown that ordinary wood is almost completely eaten by tarets at the end of a few years, whilst in the same conditions well-creosotised wood is not appreciably attacked.

Large quantities of timber prepared in this manner have been employed in England on the works of several important ports, notably at Leith, Holyhead, Portland, Plymouth, Brighton, and Southampton.

When these varieties of timber are attacked by tarets or perforating molluscs, it is proved that they adhere to parts of the wood insufficiently impregnated or where blows of the hammer have laid bare the portion not reached by the oil of tar.

This process is, however, rather expensive; it is only applied to timber recently felled, communicating to it a very disagreeable odour. It also renders the wood very combustible, which precludes its employment in the building of houses or ships.

LÉGÉ AND FLEURY PIRONNET APPARATUS.

This apparatus is based upon the same principles as that of Bréant, and differs slightly from that of Bethel. The cylinder or recipient containing the pieces to be injected is of copper, so that sulphate of copper can be employed as the antiseptic agent.

This apparatus (Fig. 158) is composed of a cylinder M about 33 ft. long by about 5 ft. in diameter. This cylinder is terminated at one of its ends by a convex bottom fixed by rivets. At the other end, a cap, also convex, moves on a hinge, and can close the cylinder in a perfect air-tight manner. The body of the cylinder is formed of twelve drums, joined by double rows of rivets. It can be divided into two parts, so as to be the more easily transportable. The walls are 10 mms. thick, and can resist a pressure of at least 13 atmospheres. This interior pressure is measured during the operation by means of a manometre. A carriage O, provided to carry the pieces of wood to be prepared, is placed

upon a truck, or if the arrangement of the road demands it, upon a system of two trucks. It can therefore be brought opposite the opening of the cylinder, upon the interior rails of which it is made to run. A movable steam-engine N, capable of developing from ten to fifteen horse-power, serves as generator for the steam, which must be made to penetrate into the cylinder by the tube *a*, actuating either the air-pump or the injection-pump. A worm placed in wooden vats R R, containing a solution of sulphate of copper to the standard of 2 per cent., receives the

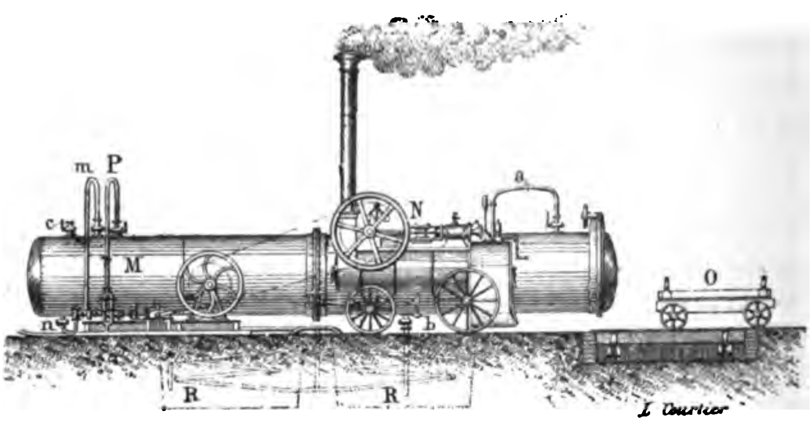


FIG. 158.

steam current, which, after having traversed the cylinder, assists in raising the temperature of the solution.

Another part of the system P comprises—

(1) An air-pump;

(2) A condenser;

(3) A suction and force-pump combined.

The air-pump communicates, by suction valves, with the upper part of the condenser, to which another tube *m* joins, giving issue to the steam contained in the recipient, as well as the small quantity of air or gas which may be found there.

The gas and steam come into the condenser as soon as the pump is put in action, and commence to make the vacuum there. The steam is brought back in a liquid condition, and the non-reduced gases pass into the body of the pump, as well as the wash of the condenser, and are afterwards repelled by the movement of the return of the piston in a cast-iron cistern. The latter is placed above the pump, communicating with it by means of expulsion valves. The cistern is filled to the level with a wash of a certain quantity of water, which intercepts the communication of the organs of the pump with the exterior air. The condenser is fed by a reservoir, with which it communicates by means of

a tube provided with a cock, the handle of which is moved upon a graduated circle, the opening of which is conveniently regulated.

The vacuum produced by the action of the pump determines the exhaustion of the air of the reservoir and its injection into the condenser, even at the time when the steam from the cylinder reaches there.

Jets of cold water can also be pumped in.

The double-action pump is pierced at each of its extremities by two openings, one furnished with a suction valve, the other by a repelling valve.

The suction openings can be placed in communication by means of cocks, either with the casks, or with a reservoir of pure water. The repelling openings communicate, by means of cocks, with the cylinder, the boiler of the impeller, or with the condenser.

When the filling of the cylinder is commenced, the two suction apertures are put in communication with vats R R, by means of cock *b*, and the two repelling apertures with the cylinder. But at the end of the operation, in order to obtain slowly and without difficulties the filling of the receiver, and the compression of the liquid, only one of the suction apertures is allowed to communicate with the cisterns, namely, that one at the head of the body of the pump. The corresponding repelling aperture is likewise only placed in communication with the cylinder. From this moment the filling is, in reality, only done by means of a single action pump.

The second exhaust aperture can then communicate with the reservoir, and consequently the corresponding repelling aperture serves to bring the water into the boiler of the impeller, into the condenser, casks, and finally upon every other point where it can be utilised.

This arrangement presents several advantages: it does away with the employment of a second and smaller injection pump in order to finish the compression in the cylinder; it does away with a third pump for water; and, lastly, it contributes towards maintaining the regularity of the movement of the apparatus.

The operation being finished, the emptying cock *b* is opened, the liquid is made to run into vats R R; after having opened air-cock *c*, the wood is withdrawn and left to dry under sheds.

By the aid of this apparatus, 1600 sleepers or 600 telegraph poles can be daily prepared.

The quantity of preserving liquor, usually composed of 2 kilogs. of sulphate of copper for 100 litres of water under a temperature of 45°, is very changeable, according to the nature of the wood, its age, how long since it was felled, and especially its volume at the time of the experiment.

The time between the moment of cutting up and that of injection brings notable differences in the mass of liquid absorbed, as can be proved by an examination of the following table, which resumes the observations made on this subject:—

Varieties.	Time.		Cube of each Piece.	Weight.		Weight of Absorbed Solution.	Increase of Weight per Kilog. of Wood.
	Of Felling.	Of Sawing.		Before Operation.	After Operation.		
			Metre.	Kilog.	Kilog.	Kilog.	Kilog.
Yoke-elm . .	10 years.	8 years.	0·046	33·90	62·00	28·10	0·83
Beech . .	5 years.	4 years.	0·093	71·60	119·50	47·90	0·68
,, . .	5 months.	2½ months.	0·056	47·00	69·00	22·00	0·47
,, . .	...	...	0·057	47·50	71·60	24·10	0·55
,, . .	...	...	0·052	44·00	64·00	20·10	0·45
,, . .	...	...	0·051	42·00	61·50	19·50	0·46
,, . .	...	...	0·062	50·70	73·90	23·30	0·52
,, . .	...	...	0·019	15·80	22·60	6·80	0·43
,, . .	4 months.	2 months.	0·104	75·00	121·50	46·50	0·62
,, . .	...	...	0·104	65·00	108·00	43·00	0·68
,, . .	16 months.	2½ months.	0·100	71·50	111·00	39·50	0·55
,, . .	4 months.	2 months.	0·104	73·00	114·80	41·80	0·57
Maritime pine .	6 months.	...	0·097	56·00	98·60	42·60	0·76
,, .	...	...	0·084	45·00	83·00	38·00	0·84
,, .	...	...	0·097	59·90	104·00	44·10	0·73
,, .	...	...	0·076	45·70	85·30	39·60	0·86
Beech . .	5 years.	4 years.	0·377	27·00	47·00	20·00	0·74
,, . .	15 months.	45 days.	0·095	78·60	133·00	55·00	0·70
Maritime pine .	4 months.	...	0·098	76·00	124·00	48·00	0·63
Poplar . .	...	In logs.	0·112	65·00	106·00	41·00	0·63
Fir . . .	...	12 hours.	0·081	60·00	102·00	33·00	0·48
Oak . . .	...	3 months.	0·059	53·00	66·00	13·09	0·24
Chestnut . .	...	...	...	155·00	213·00	58·00	0·37

For the success of the operation, it is necessary to work with healthy and very straight timber, without traces of rot or cracks, for the liquid introduced taking the line of least resistance would pass through the cracks without penetrating the wood.

Trees felled from the month of December to the month of March should be placed in preparation from the beginning of March to the end of May, and those cut from March to December should receive the preserving liquid within a fortnight after felling.

The branches and top of trees should be lopped immediately after the felling of the tree. Moreover, one must be careful to leave at each end of the pieces a length of about 10 cms. over and above the length of the piece to be prepared, so as to freshen it at the time when it is put into preparation.

The abutment of the tree and the portion of the top, which is too small to be of use in traverse-making, must only be cut at the time when the pieces are about to be removed to the timber merchant's yard.

The object of these different precautions is to avoid coagulation, which would have the effect of forming, in the sappy canals, a series of

diaphragms capable of holding back for several hours a liquid column 10 metres high, thus arresting progress for two or three days, and which can even prevent in a complete manner the preparation of timber which had been exposed to the sun during the height of summer.

The duration of the preparation is from forty-eight to sixty hours for timber of average dimensions, felled in a convenient season and coming from varieties such as the yoke-elm, beech, birch, plane, and sycamore. A hundred hours is sometimes necessary to prepare pieces of beech of a diameter of 0·80 m. by 2·80 m. long.

It is generally admitted that the duration of the preparation varies in proportion to the bulk treated and in direct relationship with the diameter.

The timber of the oak, elm, cherry-tree, all sorts of poplars, the resinous varieties, and acacia take longer to prepare, requiring from five to eight days.

Henceforth it can be concluded that this process has several advantages over the Boucherie system, which will shortly be described:—

(1) The time which elapses between the felling and the putting into operation has no appreciable influence over the penetration of the antiseptic liquid.

(2) The squared wood is prepared as well as rough wood, which is an important advantage.

(3) In the Boucherie process it will be seen that the body of hard timber is never penetrated, and if cutting-up happens to lay bare this part of the wood, one can never be assured as to its preservation; this has not to be feared with the process just described.

BLYTE-THERMO-CARBOLISATION SYSTEM.

This particular process of preservation of timber rests upon the fact that the heat-producing vapours of water and creosote mixed become the introducing agent in the mass of the wood of the antiseptic principle of phenic or carbolic acid, of which mention has already been made: hence the denomination *thermo-carbolisation* given to this process.

In several cases the creosote preparations have been recognised as being efficacious only in so far as the injection of the antiseptic matter was complete, and this latter result is often only obtained upon the condition of employing up to 20 kilogs. of heavy oil, which, whilst admitting an average price of 5s. per 100 kilogs., brings forward the price of the first matter to 1s. per sleeper; whilst in the injection of

the sulphate of copper, one can usually count that 500 grms. of salt is necessary, or about 3d. per sleeper.

There is, therefore, from this fact a marked disadvantage to the detriment of creosote, and that arises from the difficulty experienced of disseminating the heavy oil very regularly, or at least employing large quantities of it.

The use of creosote in the vaporous condition has then been tried, but it can only be obtained in this manner above 300°, and the application of so high a temperature disaggregates the wood.

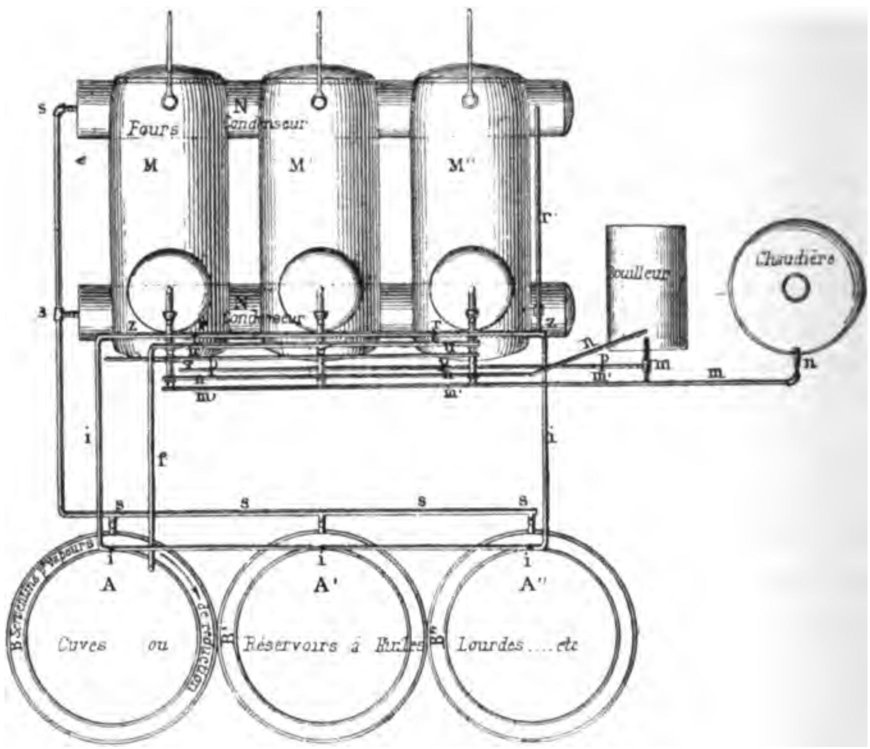


Fig. 159.

In 1870 M. Blyte disseminated heated creosote in a spray of steam at 4 or 6 kilogs. pressure, the steam operating on the lower surface of the creosote, then saturating with this carburetted vapour the timber in a closed vessel.

It completely penetrated the centre of the wood of oaks, pines of Landes, and red beeches, this penetration, which was formerly very difficult, being made with heavy oils, coal tar, vegetable tars, etc. From 2 to 3 kilogs. of creosote per large sleeper and 2 kilogs. of brown phenic acid per cubic metre of picked wood or sleepers can more generally

be employed, mixed with about 150 litres of water per metre. Success of the operation depends on the correct proportion of phenic acid.

The ordinary apparatus useful in preparing sleepers can be taken to pieces and easily transported into timber merchants' supply-yards; it is composed of four distinct parts (Figs. 159, 160, and 161):—

(1) A boiler mounted on wheels, of fifteen to twenty horse-power, at high pressure, giving steam at 6 kilogs. pressure.

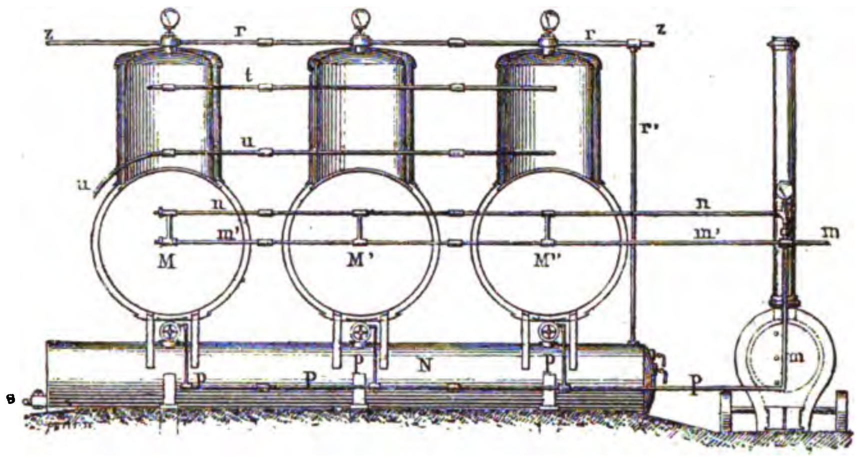


FIG. 160.

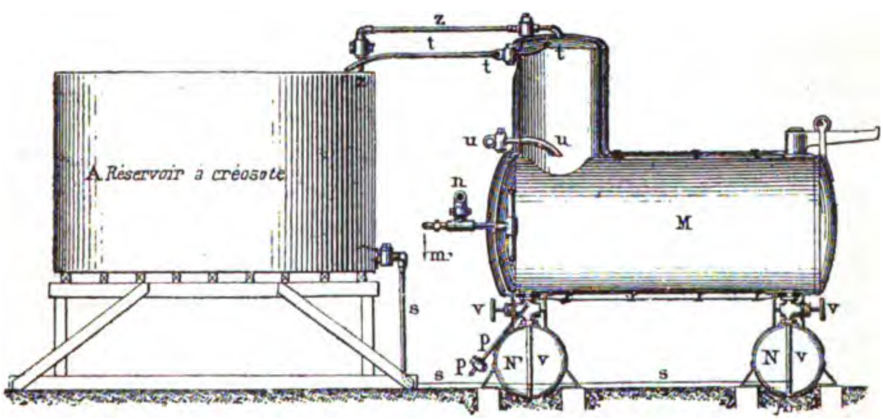


FIG. 161.

(2) A small horizontal boiler upon wheels, with ordinary hearth containing creosote and water, called the *bouilleur*.

(3) Three vats or reservoirs A A′ A″, of sheet-iron, with uncovered surface, containing heavy oil, which is made to pass into the boiler-tube, according to requirements, by the aid of a pump.

Worms B B′ B″ receive the vapour, to heat, agitate, or melt the creosote.

(4) The preparation apparatus, which comprises three sheet-iron cylinders M M′ M″ with steam chambers, safety plugs, and mobile caps on the rear of the apparatus. These cylinders, which are enveloped, can maintain a pressure of 6 kilogs.

The wood to be treated is introduced, and the domes serve to store up a surplus of heavy oil or a mixture of this matter with the products of condensation, when it is desired to bathe the injected wood by a first treatment and to verify the proportion of absorbed liquid during this bath.

Two long sheet-iron cylinders N N′ called condensers are arranged perpendicularly at each end of the ovens, and can resist the pressure of 3 kilogs. They contain the heavy oil and residues of the operation.

The system of pipes comprises eleven groups, namely—

m Pipe through which the vapour penetrates from the copper into the boiler. The steam is blown upon the lower surface of the creosote mixture.

m′ A steam pipe directed in front of the bottom of the three ovens, having three bends to introduce the steam by the axis of the ovens.

n Pipe taking the carburetted vapour to the surface of the mixture contained in the boiler, and conducting it into the three ovens by the same axis of entry as the uncreosoted steam.

p Pipe of communication between the bottom of each oven and the lower surface of the boiler, so as to bring back in the latter the matters which are condensed in the ovens.

r Pipe starting from the domes of each oven to make them communicate, so as to equalise the pressure in the ovens.

r′ Pipe connecting with the preceding, establishing the communication of each oven with the two condensers, with the object of utilising the steam of the domes to work the rising of the liquid mixture of the condensers in the oven, in order to bathe the timber there.

s Pipe of communication between the vats and condensers, so as to fill these latter with carburetted liquid matter destined for the bath.

t Pipe of communication between the dome of each oven and the exterior air, by which the steam of the ovens can escape according to requirements; the surplus of the liquid in a vat can pass off through this pipe.

u Pipe of communication between the exterior and the bottom of each dome of the ovens, by which the bath may be kept at a proper height.

v Six large pipes causing the bottom of the ovens to communicate with the bottom of the condensers, and serving to condense the steam of the ovens or to establish the rising of the liquid mixture of the condensers towards the ovens.

z Pipes containing those of *r* and causing the steam of the domes to communicate with the liquid creosote in the vats.

The preparation is accomplished thus: Having completely isolated the first oven, the advent of the steam vapour and carburetted vapours are worked simultaneously through the centre of the oven (it must be noted that creosote is disseminated in the midst of the steam vapour). The carburetted vapours, carried away by the steam vapours, attack briskly and penetrate the wood; the operation is commenced.

The communications of the oven, boiler, and condensers are then worked. A continuous circulation of the steam is set up, and of a part of the condensed mixture of steam and creosote.

The pressure rises from 4 to 6 kilogs. in the oven about half an hour afterwards; it is maintained thereat for about the same time. The timber is then completely prepared.

The operation of the following oven is begun by making it communicate with the oven provided to equalise the pressures, and after the isolation of this latter by proceeding as above.

Though this preparation may be the principal one, it can be completed, for example, in the case of sleepers. For these, either the dome of the second oven or the copper is placed in communication with the condensers containing creosote and water, with a portion of the products of condensation. This liquid, heated by the steam, rises and bathes completely the softened timber. The surfaces and sapwood can be penetrated by it.

The apparatus just described is capable of preparing five hundred sleepers per day. The wood comes out very tender, and can be shaped by pressure, ground, and bent. It hardens easily, and can be employed for roadways a few hours after leaving the oven.

When the quantity of oil able to enter into combination in the wood is employed, the tint of the latter, as well as its aspect, are not changed. The wood becomes denser, the pores are closed up, it is more greasy for sawing, and polishes more easily.

Molecular contraction is probably established shortly after the operation; but at the end of a few weeks the timber is no longer influenced by the temperature, the pieces harden in the air, and become unattackable by damp. The fibres are more resistant in the torsion

tests, and the uprooting trials indicate an appreciable increase of resistance.

By prolonging the operations deep and uniform tints can be given to the timber, which in certain applications embellish it.

The net price of a long sleeper cubing 0·085 m., allowing of the employment of 2 kilogs. of creosote, is about 6d.

The advantages arising from the employment of this process are important.

The qualities of the wood, strength of the fibres, resistance to uprooting, are augmented.

With freshly-cut timber the work is more rapid than in any other process.

One can, as in the other processes, employ the supplementary means of preservation of the sapwood by a bath at variable pressure, but under better conditions and with less raw material.

Timber can be employed in building a few months after preparation, which can be done as soon as the tree is felled.

The price of preparation, estimated at 6d. per sleeper, is less high than that of the preparation in a closed vessel by means of sulphate of copper, which rises to about 8d., and especially lower than that of the ordinary creosote preparation, for which 1s. 3d. per sleeper may be reckoned.

The pine of the Landes and that of the North, thus injected, can be compressed and serve for paving. Finally, the timber of the beech and oak can, after having been conveniently tinted, be of use in furniture-making, after the odour of the preparation has disappeared.

CHAPTER XXI.

THE BOUCHERIE SYSTEM, BASED UPON THE DISPLACEMENT OF THE SAP.

M. BOUCHERIE applied himself to green, unbarked wood; he favoured the view that it is necessary to introduce the preserving liquid by profiting by the natural movement of the sap. This movement can be aided by suction or by pressure, so as to expel all the sap and permit the combination, in all parts of the wood, of the antiseptic with putrescible elements. It follows that, in this process, the closed vessel employed in the preceding systems is not required. Simple suction or hygrostatic pressure is sufficient to favour the filtration of the liquid in the pores of the wood. This system has been successively improved. So enthusiastic

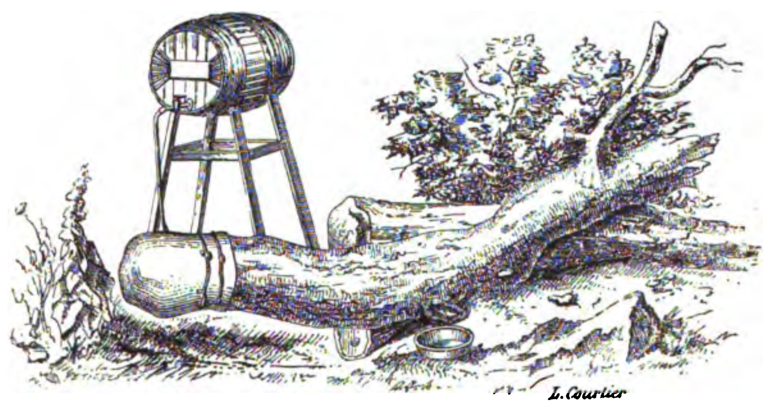


FIG. 162.

were the French people in 1856 by this discovery that a special law protracted the Boucherie patent by way of national recompense.

In order to practise this injection system, the felled tree is immersed in a vat containing the liquid to be absorbed by the wood. It is not necessary for the tree to be standing to ensure this absorption taking place; success has been obtained with a felled tree (Fig. 162), provided it be in contact with the liquid; one can even make at the base of the

tree, holding by the roots, a kerf of the circular saw, and surround it with a sort of basin containing the liquid; this latter does not take long to become completely absorbed and to penetrate all the tissues.

A second process consists in piercing with a gimlet some holes at the foot of a tree (Fig. 163) still rooted in the soil; the preservative liquid is introduced into these holes, its ascent in this case being rapid and complete.

For this operation one can remove all the branches and lateral leaves of the tree, provided that a tuft of leaves determining the ascent be reserved at the top.

In 1841 M. Boucherie conceived another method based upon the

FIG. 163.

displacement and expulsion of the sap by means of the pressure and filtration of the liquid to be injected. The *modus operandi* was as follows:—The pieces of timber, after having received at each end a cut of the saw to refreshen the surfaces of them, are extended parallel with a slight inclination (Fig. 164). One applies, upon the section of the large end—which will be the surface of penetration—a wooden disc of the heart of an oak, after having sometimes placed, upon the periphery of the surface, a dry rope of hemp tow. The wooden disc is pressed firmly against the tree, and is kept there by means of iron hooks. An empty space of some millimetres is thus made, which serves to house the antiseptic liquid with which it is intended to treat the entire section of the wood. The wooden disc is pierced in places by a circular opening, in

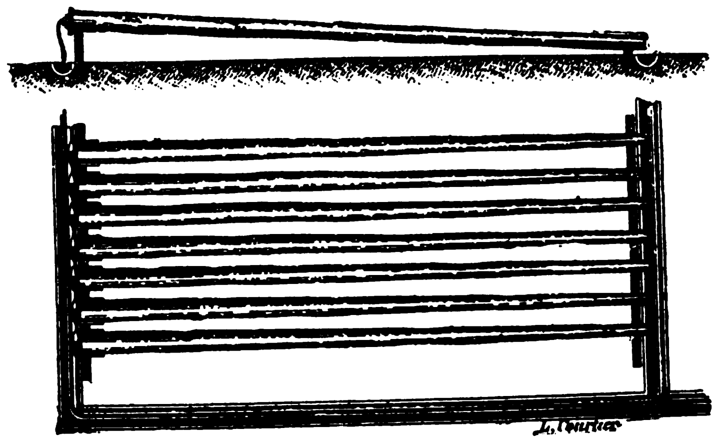


Fig. 164.

Fig. 165.

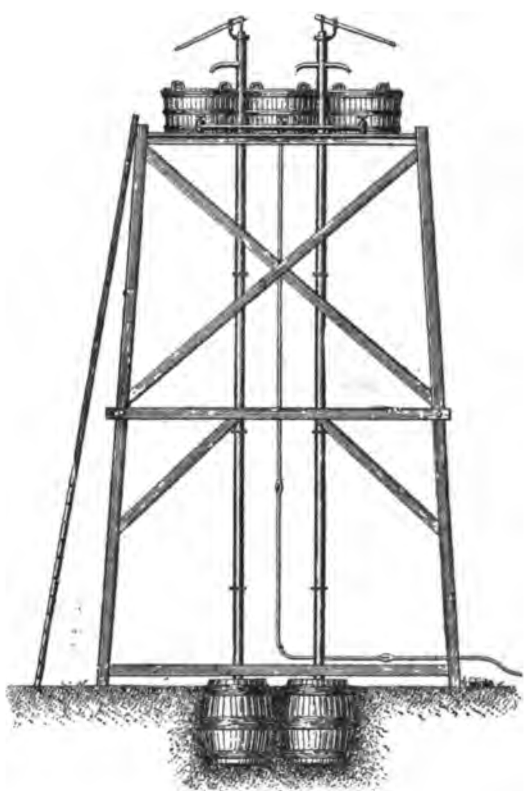


Fig. 166.

which the end of a hard wooden tap called a *robignole* (Fig. 165) is forcibly introduced, which transmits the liquid which a reservoir placed 26 or 33 ft. high conveys to it. When the cock of this reservoir is opened, the weight of the liquid soon thrusts before it the water of vegetation and the nitrogenised principles which it contains. This water flows through one of the ends of the trunk of the tree and the preserving liquid replaces it. The operation is finished when nothing but saline solution instead of sap comes from the trunk.

The liquids employed vary according to the results which it is desired to obtain. If it is a question of preserving timber from dry or damp brown rust, to increase its durability and assure its preservation, M. Boucherie proposes to employ pyrolignite of iron, or more commonly sulphate of copper. Chlorides of the alkaline earths may be employed when it is desired to preserve the suppleness of timber.

The introduction of saline substances into the interior of timbers has the great advantage of preserving them from *voilage* and shrinking, making them in some measure incombustible. The displacement of the sap by saline solutions is very prompt. Thus, a poplar of 0·40 m. diameter at the base absorbed in six days 3 hectolitres of pyrolignite of iron. A wooden plank of 0·30 m. absorbed 2 hectolitres of chloride of calcium in seven days.

It has been proved in the Compiègne Forest that, of a beech cubing 294 cubic metres, 3060 litres of pure sap have been displaced in twenty-four hours, which have been replaced by 3210 litres of pyrolignite. This last experiment permits of establishing the relation which exists between the solid part of the wood and the fluid circulating in the sappy canals.

It is interesting to know how the sulphate of copper injected into wood is preserved. To ascertain this, comparative analyses have been made of freshly prepared timber, in course of service and in different degrees of decomposition. Timber freshly prepared contains, in the free state, a large quantity of injected sulphate. Placed in use, especially planted upright in the soil, they lose this sulphate by degrees, without, however, becoming altered, and posts are often met with of long usage no longer presenting a trace of free sulphate, and which are in an excellent condition.

This consideration causes it to be supposed that it is not only free sulphate which is the preserving agent, but that, on the other hand, the antiseptic action is accomplished more particularly by a certain quantity of sulphate of copper, combined with the elements of the wood and fixed in its tissue. It is this, indeed, that happens. Thus, when a piece of

injected wood is reduced to powder and the sawdust obtained is washed, it is easily and completely freed of the sulphate of copper which it contains; then, if it is afterwards incinerated, the ash treated by an acid, the liquid and washing water of this ash collected, a fresh quantity of copper will be found in these liquids; it is therefore the fixed copper in the wood which is the principal preservative agent. Moreover, this quantity of copper is appreciably in definite proportion with that of the experimented wood. An injected tree therefore contains a salt of fixed copper.

When, on the other hand, copper in putrefied wood is sought after, not only does one find none in the free state, but the amount of that fixed diminishes in proportion as decomposition advances.

Young trees are penetrated better than those which are older.

It must be added that this process of wood preservation is subject, either in the details of the operation or on account of the more or less favourable disposition of the molecular state of the wood, to variations which may render the preparations incomplete and give rise to miscalculations.

The conditions to be fulfilled to ensure a good result are numerous, and it is difficult not to omit one or other of them.

This injection system presents a grave inconvenience, namely, the diminution of resistance and elasticity which it produces in the wood. The pores of the wood whose sap is expelled are, indeed, submitted to forced dilatation, destroying the natural cohesion of the fibres, and thus weakens their resistance and elasticity. This result is the more marked as the timber which is treated is lighter. There is still another disadvantage, namely, after the contraction which follows the swelling necessary to injection, vacuums are left which give more facility to the introduction of atmospheric agents capable of altering the composition of the wood; this circumstance may also explain why incompletely prepared pieces are destroyed so quickly.

To resume, if the two processes with sulphate of copper and creosotised oil are compared in the preservation of timber, the following conclusions will be arrived at:—

Sulphate of copper is toxic for plants and parasitic animals which make their appearance at the beginning of organic decomposition.

The sulphate should be employed in excess when the timber is intended for immersion in water or burying in damp soil, because the water slowly carries off the salt by dissolving it. For protection from sea-water, sulphate of copper will not suit.

In timber penetrated by salt of copper, a portion of the sulphate

unites closely to the woody tissue, and another part of the same remains free; this last fraction, first dissolved and carried away by exterior liquids, alone retards the removal of the metallic salt combined with the wood; but this combination itself, though more stable, does not escape subtraction, accelerated or retarded according as the dissolving liquid is renewed more or less quickly.

On the other hand, the amount of metallic salt should be diminished in timber destined for buildings, in order to prevent the mechanical effect of intravascular crystallisations.

Finally, the copper solution ends by becoming charged with organic elements prejudicial to the success of the operation.

Creosotised oil is preferable for injection of shipbuilding timber.

The volatility and solubility of certain antiseptic agents contained in this oil would render the efficacy of their action merely momentary, if the more fixed and thicker oils accompanying them did not contain and retain these volatile compounds, at the same time obstructing all the pores of the wood, leaving difficult access to the dissolving liquids and destructive gases.

It must, finally, be mentioned that the use of metallic salts, and notably of sulphate of copper, makes the timber incombustible, whilst the opposite is the case when tar or oil produced from it is employed.

CHAPTER XXII.

PROCESSES FOR MAKING TIMBER UNINFLAMMABLE.

IT is scarcely necessary to insist upon the importance, in numerous cases, of being able to make timber safe from the attacks of fire.

Now, at 300°, all varieties of timber prepared by any one of the preceding processes are completely carbonised exactly as if they had received no preparation, the decomposition occurring, moreover, without the production of flames.

Brought to red-heat or submitted to the action of an inflamed body, the pieces prepared are entirely destroyed. However, it often happens that the destruction is limited to the places attacked by fire.

Timber covered by a suitable coat offers a certain resistance to fire, but the caloric soon finishes by reaching the interior, and the destruction of the wood is effected.

Generally speaking, it is not possible to make wood incombustible, but the uninflammability can be assured of, and the destruction at the points directly attacked by fire can be localised.

Numerous processes have been proposed; the principal ones only will be noticed.

M. Folbarri recommended the employment of the following mixture:—

	Kilog.
Sulphate of zinc	24·75
Pearl-ash	9·90
American alum	19·80
Oxide of manganese	9·90
Sulphuric acid at 60°	9·90
Water	24·75

All the solid matters are introduced into a copper containing water at a temperature of 45°. As soon as they are dissolved, sulphuric acid is added by degrees until complete saturation.

To prepare the wood, it is arranged in a special apparatus upon iron grills, taking care to leave a space of about 1 cm. between each

piece. After this, the liquid is injected, by means of a pump, into the apparatus, and when all the empty spaces have been filled, it is heated for three hours. At the end of this time the timber is withdrawn and placed upon grills, where it is allowed to dry in the open air.

The following mixture has also been proposed:—

Sulphate of ammonia	8
Carbonate of ammonia	2
Boric acid	3
Pure borax	1
Starch	2
Water	100

The tissues and the wood impregnated with this solution are proof against fire, even after having been heated for a certain time in a drying-stove at 35°.

Some years ago a process was described rendering timber uninflammable by the employment of tungstate of soda.

One proceeded in this manner:—

Commercial tungstate of soda is dissolved in warm or cold water; from 1·130 to 1·360 grms. of salt are employed for about 4 litres of water, so as to obtain a solution with a specific gravity of 1·20.

The timber can be impregnated warm or cold either by immersion or pressure. It is, however, preferable to operate with a warm solution. When the wood has become dry the fibres and intercellular spaces are covered with tungstate; it acquires very great durability, resisting the action of the heat well.

White and red pines, thus treated, assume the appearance of oak, and are substituted for it for different uses.

The best process noted up to the present is that in which soluble glass (water-glass) is utilised.

To prepare the timber, two or three layers of weak solution, prepared by diluting 1 volume of syrupy solution of silicate of soda with 3 volumes of water, are first given to it; the timber becomes rather strongly impregnated with it. This first coating being almost dry, a layer of ordinary whiting is applied to it.

The lime washing being almost dry, it is fixed by a more concentrated solution of soluble glass, prepared by a mixture of 2 volumes of syrupy solution with 3 volumes of water.

A second application of this same solution is only necessary in the case where the whiting has been employed too thick.

Experiments practised upon wood thus prepared show that the coating offers great resistance to the action of heat; this coating does not become

detached from the surface of wood highly heated; it prevents for a long time the wood burning with a flame, even when it is submitted to the influence of intense heat.

Rain has no influence over it. Submitted to the action of an energetic water spray, it is but very incompletely washed, and only at the end of a very long time.

In general, 1 kilog. of soluble glass is sufficient to thoroughly prepare a surface of 2 square metres of wood.

Interesting experiments, about to be recapitulated, were but a short time ago made in Belgium upon this question of inflammability of wood.

Specimens of twenty different varieties of wood were prepared; they were then cut up into sticks of about 15 mms. of section, and exposed to the action of a certain number of gas jets.

It has been proved that ordinary non-prepared wood is, on an average, inflamed after one and a half minutes, continuing to burn even when removed from the hearth.

Bundles of eight preparations by injection of metallic salts should have been removed at the end of eight to ten minutes, their inflammation having become complete. Among these latter, those which resisted the most are the timbers injected with tungstate of soda, chloride of calcium, and sal-ammoniac.

The other preparations, by painting or washing, have resisted for from thirty to forty minutes; the best results were given by timber covered with soluble glass, with addition of kaolin, pounded glass, and whiting, by those injected with phosphate of ammonia, and by those covered with asbestos paint.

The following are the conclusions to which these experiments have led:—

(1) The incombustibility of timber is not realisable, but one can obtain an uninflammability sufficient to preserve all buildings exposed to limited danger, or at least to permit of awaiting help.

(2) The processes of preservation are of two kinds—by injection of saline solution or by painting.

(3) The injection processes only give good results, from the point of view of uninflammability, if phosphate of ammonia in concentrated solution is employed.

(4) Preservation by means of painting is the only process to be employed in almost all cases. Those paintings which are most highly recommended are—

(*a*) Painting with soluble glass.
(*b*) „ „ kyanite.
(*c*) „ „ asbestos.

METALLISATION OF TIMBER.

Before leaving this subject, we will say a few words as to a special mode of preservation, very interesting from the point of view of the result to which it leads. Timber prepared by this process acquires a very brilliant metallic lustre.

It is commenced by treating the timber with a caustic-alkaline solution (calcareous soda), and it is left in this bath for from three or four days, according to degree of permeability of the wood, at a temperature of 75° to 90°. Thence the timber passes immediately into a bath of sulphohydrate of calcium, to which is added, after twenty-four or thirty-six hours, a concentrated solution of sulphur in caustic soda. The duration of this bath is about forty-eight hours, its temperature varying between 35° and 50°. The timber is immersed in a solution of acetate of lead, also heated to about 50°, for about thirty to fifty hours.

The process is rather long, but it furnishes very remarkable results. Timber thus prepared, after having been conveniently dried, assumes, under the burnisher, a very brilliant polished surface. This brilliancy increases if the surface of the wood has been previously rubbed with plates of lead, tin, or zinc, and if it is afterwards polished with a burnisher of glass or porcelain. In this manner timber may be given the appearance of a veritable metallic mirror, very permanent and resistant.

PART VI.

APPLICATIONS OF TIMBER.

CHAPTER XXIII.

GENERALITIES—WORKING TIMBER—PAVING—TIMBER FOR MINES—RAILWAY TRAVERSES.

GENERALITIES.

As already mentioned, the applications of wood in general are most numerous, various, and important. Each time that the opportunity has presented itself, *à propos* of the succinct description of the different varieties which have been given, the principal applications of each description of timber have been pointed out, and it therefore only remains to give some details as to the principles of these applications.

It will at once be seen that timber can serve either in the state of wood properly so-called, or in an unnatural condition.

Thence there are two large divisions.

In the first will be ranged all the applications of wood considered as firewood and timber for working, building, joinery, cabinetmaking, etc., with the applications of its different accessory products, gums, resins, oils, paper-pulp, etc.

In the second, the applications for tanning, dyeing, and industrial chemistry in general will be described.

The principal applications of timber will therefore be studied in this order, at once pointing out that we have already spoken sufficiently of timber considered as a combustible in the course of this study, that it does not enter into our programme to treat of its important application in charcoal-making, nor of the vast use at the present time made of it in papermaking, these different points having been treated,

with special details, in two other works, to which the reader is referred.

Let us first recapitulate the information already given as to the particular and special applications of each variety.

Those kinds of timber of the best quality for each usage will be placed in the front rank, followed by varieties of poorer quality.

Charcoal.—Sylvester pine, yoke-elm, sycamore, ash, beech, oak, birch, elm, larch, pitch, common fir, aspen, lime, and alder.

Firewood.—Sycamore, pine, ash, beech, yoke-elm, service-tree, oak, larch, elm, pitch, birch, common fir, lime, aspen, alder, black poplar, willow, and Italian poplar.

Shipbuilding.—Oak, fir, pine, larch, beech, and elm.

Large Building Timber.—Oak, chestnut, and pine.

Scaffolding. — Elm, service-tree, beam-tree, apple-tree, and yoke-elm.

Ordinary Timber.—Oak, chestnut, resinous trees, elm, service-tree, beam-tree, cherry-tree, aspen, and poplar.

Clap-boards.—Oak and beech.

Laths.—Oak, chestnut, and white wood.

Bushel-making.—Oak, beech, fir, and aspen.

Trellis-work.—Oak, chestnut, and ash.

Vine-props—Oak, chestnut, ash, pine, willow, and aspen.

Fencing.—Chestnut, juniper, dog-berry, oak, ash, pine, hazel, maple, and white wood.

Sawing.—Oak, ash, elm, platane, chestnut, larch, fir, pine, wild cherry-tree, linden, French chestnut, black and common poplars, and aspen.

Scraping.—Beech.

Bowls and Platters.—Beech, fir, pine, and aspen.

Vices and Tables.—Elm, beech, and nut.

Timber-piles.—Oak and alder.

Ordinary Carriage-making.—Oak, ash, elm, and yoke-elm.

Carriage Work de Luxe.—Ash, elm, oak, beech, and nut.

Water-conduits.—Pine and alder.

Hoops.—Chestnut, ash, willow, wild cherry, birch, hazel, ash, white willow, and lime.

Turning Wood.—Ash, nut, false acacia, plum, and box.

Wood for Sabots.—Beech, nut, birch, alder, common poplar, aspen, lime, and Italian poplar.

Sculptors' Wood.—Oak, ash, platane, lime, and French chestnut.

If, now, the relative value of each kind of timber is estimated by

the variety of the commodities obtained from them or by the number of usages to which it is adopted, it will be found that our forest varieties present themselves in the order as follows:—

Oak, beech, ash, elm, chestnut, yoke-elm, resinous trees, lime, aspen, birch, and alder.

All the other varieties are only of secondary usefulness.

As for the timber specially intended for cabinetmaking, we find among our indigenous descriptions the wild cherry, dog-berry, nut, pear, apple, box, arbutus, plum, maple, and service trees, and afterwards numerous exotic varieties, among which may be mentioned the mahogany, aloes, caïlcedra, cedrel, lemon, orange, locust, ebony, ironwood violet ebony, teak wood, tuya, etc.

TIMBER.

All wood, excepting that used for firewood, is called timber, and this is used in buildings or in furniture making and other industries. The different kinds of timber can be differently classified according as they are adapted for shipbuilding, housebuilding, for carriage work, or for other purposes.

The employment of timber in buildings dates back to the remotest antiquity, but it has undergone, with time, decided transformations.

Upon the appearance of civilisation, the tree supplied almost all the essential materials of the house.

Elementary and massive carpentry demanded entire trunks, which, merely chipped, placed flat or standing, and roughly tied one to another, bore the whole weight of the edifice. The larger the construction, the stronger had the pieces of timber to be.

But in proportion as the primitive forests receded before the progress of agriculture, timber of huge size ceased to be common material. By degrees it has become more rare and dearer; it is necessary to bring it from afar, and precisely at the period when the taste for large buildings, awoke by the Renaissance, spread,—at the time when the imitation of ancient monuments rendered necessary wonders of equilibrium and strength in the beams and supports, — large timber disappears.

Philibert Delorme has described in a celebrated work the processes invented by him to make up for the scarcity of large carpenters' timber. Thanks to the folding form which he gives to the roof, as likewise to other artifices of construction, thanks especially to the bonds which he conceived and which are to-day of current employment, he could build

the roof-frames of the largest castles, and that "*without making use of large purlins, sablières, beams, rafters, pousteaux, and other kinds for which it is necessary to employ large trees which in this country are very rare.*"

He thus solved the problem by "*making beams necessary for large dwellings of kings and princes, not of large wood and trees, as is done, but of three, four, or five hundred pieces of small timber and of all descriptions.*"

But the scarcity of large timber, which necessitated in the sixteenth century this great economy in materials, has enormously increased since. This is one of the reasons which has caused one to think of eliminating the timber in ordinary constructions and replacing it by iron.

Timber is still in demand in buildings and the arts only because it enjoys certain properties which make it fit such or such purpose.

These principal properties, considered from the special point of view of building, are the following:—

Durability.—This property depends, first and foremost, upon the depths into which they are immersed. A very dry wood, and placed in a constantly dry earth, may last a very long time when not attacked by insects. In this respect it is the old and resinous timbers which have the least to fear. Those timbers most exposed to the attacks of worms are the yoke-elm, alder, birch, sapwood of the oak, followed by the beech and maple.

Timber continually immersed in water rots with difficulty. But the durability of the wood is very limited when repeatedly submitted to alternatives of dryness and dampness. Trees whose vessels are filled with resinous matters and whose layers are dense, withstand these alternatives more easily. Hard timber also offers more resistance than that whose cellular tissue is loose and porous.

To increase the durability of the wood, the trees should be felled when the sap is down, drying it carefully and working with it only when it is perfectly dry. Finally, recourse should be had to one of the processes of preservation already described.

Ease of Splitting.—All timber can be split by the help of wedges and hammers, but some descriptions offer the advantage of splitting easily in a clean and regular manner in the direction of their fibres. This is an important property, for certain kinds of timber require, in respect of solidity, to be split, and not cut up by means of the saw.

The timber which splits most easily is that of the oak, beech, and conifers, followed afterwards by the maple, ash, lime, aspen, and birch.

The elm, yoke-elm, and black poplar split with difficulty.

Resiliency.—This quality is only valuable united with good resistance and when the timber does not break easily.

Of all timbers, the yew is the most resilient. Yoke-elms, maples, and oaks are equally resilient when young. On the other hand, old oaks scarcely so, whilst the elm, fir, larch, pitch, ash, and aspen preserve this quality even when ageing.

Flexibility.—This is the property of curving or bending under the action of a certain force without breaking; it is greatly in demand for a number of purposes.

Flexibility can be increased by damp and heat, and under their combined influences curves and permanent shapes can be given to almost all kinds of timber without breaking them.

This property is naturally very valuable for the soft timbers employed in basket-work, bushel-making, and cooperage work.

Of the stem woods, the most flexible are the elm, followed by the young oak, ash, yoke-elm, willow, fir, birch, and aspen.

Force of Resistance.—This is measured by the more or less considerable effort which it is necessary to make in order to break the timber either crossways or in the longitudinal direction of its fibres.

The strength crossways of the fibres is about the only one considered in the crafts. Those kinds of timber possessing it in the highest degree are those whose woody layers are dense and close. The beech, ash, oak, elm, and yoke-elm occupy the first rank; other and resinous timbers are far less strong.

Density.—This can be considered from two points of view—absolute and relative density.

The first consists in the real density and the multiplicity of the woody fibres; it serves to measure the degree of combustibility of the wood.

The relative density consists in the relative and uniform manner with which the fibres of the wood are divided, and when it is high, neither fissure nor cell can be perceived.

This density greatly influences the appearance of the timber; the higher it is, the finer is the grain and the more susceptible of taking a beautiful polish.

Certain timbers possess these two densities; we will quote the box, yew, apple and pear trees, maple, and yoke-elm; on the other hand, the oak and beech have only an absolute density, whilst the horse-chestnut, lime, aspen, and willow only enjoy a relative density.

Durability.—This is measured by the resistance that the wood offers to sharp instruments, and depends partly upon the absolute density.

SHIPBUILDING TIMBER.

Three kinds of timber are employed by the navy in the building of its ships, namely, *straight*, *curved*, and *angled* timber.

The first is completely straight or slightly bent. They constitute the *half-beams*, the *castle beams*, and *plank timbers*.

This latter variety is cut into long and thick joists, which, under the name of *plankings* or *foot-walings* are intended to close, outwardly or inwardly, the hull of the ship.

The *curved* timber presents regular and continuous bent forms, without bending or turning-back points.

The *angled* timber is of straight pieces, though curved at almost straight angles, which present a curvature or conge in the middle point of this angle.

The wood principally used in naval timber-yards is that of the oak, beech, ash, elm, and resinous trees.

The timber of the *oak* is about the only kind used in Europe in the building of the hulls of vessels. The varieties furnishing almost exclusively marine timber are the *English* and *pedunculated oaks*.

Generally the keels of ships are built of beech, as this timber is very straight. Trees about a hundred years old are employed for this purpose.

The *beech*, whose wood is firm, pliant, and elastic in the damp condition, is also very well adapted for the making of oars.

The timber of the *elm* provides the navy with cutters and sloops.

The wood of resinous trees is greatly used in naval constructions. The maritime pine is useful in the sheathing of craft, and also in the making of the props which support the vessels in course of building. These kinds of timber are especially employed in mast construction.

For masting, choice should be made of trees which have grown in a good dry soil, of average age, very healthy, abounding in resin, of supple and flexible timber, very straight and not having many branches.

BUILDING TIMBER.

For building in general, almost every description of wood growing in forests is employed. Some are used as carpenters' timber, others as being adapted for the construction of large machines, and others as timber for joinery purposes.

In large civil buildings, such as those of bridges, dams, ports, and

large edifices, the forest trees furnishing timber of sufficiently large dimensions are the oak, chestnut, and fir trees.

For buildings in damp or submerged soil, for the stilts of bridges, foundations, piles, etc., the oak, elm, alder, and resinous timbers are advantageously employed.

If it is a question of building a large machine, including axle-trees, gears, pivots, etc., the oak will be utilised, or, failing that, the sylvester pine, fir, and pitch.

Carpenters' timber is generally divided into two categories—*solid* timber, which remains of natural size, and *sawing* timber, which is split by the saw into several pieces.

WORKING TIMBER.

This name is given to wood "worked" in forests or in the vicinity of them for the making of different utensils. Or the wood is merely split and dressed, and is then called *split* timber, or receives more dressing and is called *scraped* timber.

In the first case, it serves in the making of laths, vine-props, clapboards, hoops or rings, the bands of sieves, etc.

In the second case, pack-saddle stocks and saddle-bows, yokes for oxen, oven shovels, mallets and beetles, etc.

WOOD PAVING.

The application of wood in the making of causeways, etc., has during the last few years found great favour in many cities.

Paris notably has recognised for some years the advantages of wood paving upon a solid foundation of cement.

The timber of the North was at first employed, but the tendency is to substitute the Landes woods for it.

These latter present, indeed, certain advantages, namely—

(1) They wear more regularly, because they are more homogeneous.

(2) They are less inclined to rot;

(3) They dry more rapidly than timbers of the North, on account of their containing more resin.

It may also be added that the price of them is lower than for pavements of the North, the exploitation of which is reduced.

In 1889 Paris used 45,000 square metres of wood paving, of which about a half was done with the products of the Landes.

There is now 300,000 square metres of wood paving in the streets and boulevards of Paris.

This mode of paving by means of blocks placed in juxtaposition was known long ago, having been employed in England and Germany more than fifty years ago.

The following precautions are generally recommended in order to obtain a good result:—

(1) The wood should be taken from the heart of the tree; the larch and other resinous varieties furnish excellent materials.

(2) The blocks should be cut on a uniform model, the more easily to adjust them closely.

The height should be equal to one and a half times the width, because strong resistance on the sides is necessary to the stability of the road. The pieces of timber are either rectangular or in the form of hexagonal prisms; these latter are more resistant, but the net price is higher; the first form is usually the satisfactory one.

(3) The blocks should be placed upon a solid bed of pebbles, gravel, or cement, well rammed down and flattened.

(4) At the time of placing the blocks it is as well to distribute a layer of fine gravel over the area of the road thus prepared, to facilitate the adjustment of the blocks.

(5) Finally, the pavements should be arranged so as to present a perfectly level surface, before even being rammed, so that the final formation of the level does not depend so much upon the effects of the ramming as upon the horizontal nature of the pavement itself. It is essential that the blocks come from dry trees and that they be used soon after having been cut, so that this form will not vary by the warping of the woods.

These pavements generally undergo previous injection, destined to assure their preservation.

WOODWORK OF MINES.

Large quantities of timber are necessary in mining, and especially in coal-mining, particularly in the shape of props for the galleries.

Generally, the principal element of the support of passages in mines is a frame composed of four pieces of wood, namely, a hand-piece, sole, and two uprights. These pieces are usually barked and then dovetailed.

When it is a matter of a large-section passage and when the coal dust is considerable, several vertical uprights of wood are arranged in the axis of the gallery; sometimes the uprights of two adjacent frames are connected.

The timber of mines, placed in quite special circumstances, should be resistant to bending and compression; the resiliency generally increases with desiccation.

The resiliency and resistance to breaking diminish from the base of the trunk towards the top.

In mines the timber is constantly bathed by a warm and often damp atmosphere; it is then placed in very unfavourable conditions, from the point of view of preservation.

Numerous experiments have been made which have led to the classification of the timber in the following order, which is that of their durability in mines: the chestnut, English oak, pedunculated oak, wild pine, alder, ash, maritime pine, acacia, willow, maple, elm, aspen, wild cherry, birch, yoke-elm, beech, and poplar.

The birch and yoke-elm should be, as a rule, but little employed; as

Varieties.	Limit of Elasticity.		
	Green Wood.	Wood Dried.	
		In a Closed Vessel.	In the Air and exposed to Sun.
Acacia	...	3·175	3·188
Alder	1·449	...	1·809
Birch	0·761	...	1·617
Yoke-elm	0·282	...	...
English oak	...	1·936	2·349
Maple	...	...	2·715
Ash	1·726	...	2·029
Beech	...	2·018	2·317
Elm	0·987	...	1·842
Poplar	...	1·200	1·484
Fir	...	1·597	2·123
Sycamore	1·647	...	2·303
Aspen	2·302	...	3·082

Varieties.	Coefficient of Resiliency.	Limit of Resiliency.	Cohesion.	Density.
Acacia	1261·9	3·188	7·93	0·717
Alder	1108·1	1·809	4·54	0·601
Birch	997·2	1·617	4·30	0·812
Yoke-elm	1085·7	1·282	2·99	0·756
Pedunculated oak	977·8	...	6·49	0·808
English oak	921·3	2·349	5·66	0·872
Maple	1021·4	2·715	3·58	0·674
Sycamore maple	1163·8	2·303	6·16	0·692
Ash	1121·4	2·029	6·78	0·697
Beech	980·4	2·317	3·57	0·823
Elm	1165·3	1·842	6·99	0·737
Poplar	517·2	1·484	1·97	0·477
Wild pine	734·0	1·633	2·48	0·612
Fir	1113·2	2·153	4·18	0·493
Aspen	1075·9	3·082	7·20	0·602

for the lime, it must be expelled from mining passages, for it decomposes very quickly there.

We tabulate on the preceding page the results of a series of experiments due to MM. Chevandier and Wertheim upon the limits of elasticity of the principal timbers, from the point of view of their employment in mines.

It may be observed that the densities found by these observers differ in some points from those already given at the commencement of this account; the differences are in the state of desiccation in which the different specimens of the two series are found.

RAILWAY SLEEPERS.

One of the most important industrial applications of timber is that made of it in the construction and maintenance of railroads, in the form of sleepers.

The principal varieties employed for this purpose are the oak, beech, pine, and fir. We have already mentioned what the preparations were which they must undergo in order to assure as long a durability as possible.

	Production.		Consumption.			Length of Main Roads.
	France.	Other Countries.	Laid Down.	For Repairs.	Total.	
	Sleepers.	Sleepers.	Sleepers.	Sleepers.	Sleepers.	Kilometres.
West	201,596	30,000	198,802	32,794	231,596	6,261
North	259,670	...	258,704	966	259,670	5,002
East	199,055	102,385	218,263	83,177	301,440	7,397
Orleans	483,612	...	369,294	114,318	483,612	7,536
Paris - Lyons - Mediterranean	414,427	34,426	618,345	183,297	801,642	11,865
South	705,434	...	478,618	226,816	705,434	3,730
State	197,881	...	188,512	9,369	197,881	2,730
	2,461,675	166,811	2,330,538	650,737	2,981,275	44,521

From experiments undertaken in Germany in this respect, it follows that the replacing of sleepers must be operated in the following proportions:—

31 per cent. at the end of twenty-one years' service in the case of sleepers of pine injected with chloride of zinc.

46 per cent. at the end of twenty-two years' service in the case of creosoted beech sleepers.

49 per cent. at the end of seventeen years with non-injected oak.

21 per cent. after the same lapse of time with oak injected with chloride of zinc.

Everywhere where these observations have been made, the conditions were most favourable—that is to say, the road was made of materials of first quality.

The French forests are capable of providing annually as much as four million sleepers.

The table on the preceding page shows the consumption of sleepers made by the large French companies during the year 1888.

It may be remarked that the total consumption is more than the quantity received, because the resources in stock were sufficient to satisfy all requirements.

The length of the complete railways was, on the 1st January 1888, 31,474 kilometres; the figures of the last column give the length of roads over which the public trains circulate. They comprise lines with single and double lines, the latter being reckoned as twice their length.

As for the division of the varieties of timber employed in the making of sleepers in France, for the year 1888, the following figures are found:—

FRENCH TIMBER.

Companies.	Oak Sleepers.	Beech Sleepers.	Fir-Pine Sleepers.	Totals.
West	108,242	93,354	...	201,596
North	51,201	206,816	1,653	259,670
East	189,573	9,482	...	199,055
Paris-Orleans	463,460	...	20,152	483,612
Paris - Lyons - Mediterranean	...	...	...	414,427
South	292,790	...	412,644	705,434
State	112,019	...	85,862	197,881
FROM OTHER COUNTRIES.				
West	...	30,000	...	30,000
North	...	...	...	...
East	85,554	...	16,831	102,385
Paris-Orleans	...	...	...	...
Paris - Lyons - Mediterranean	34,426	...	...	34,426
South	...	...	...	...
State	...	...	...	...

If we recapitulate the number of sleepers from the forests of France and from those of other countries, consumed by the French railroads

for the six years between 1883 and 1888, for the maintenance and construction of the main lines, the following figures will be found :—

Years.	France.	Other Countries.	Totals.
	Traverses.	Traverses.	Traverses.
1883	3,475,419	1,097,370	4,572,789
1884	3,823,332	1,001,696	4,824,968
1885	3,253,042	896,583	4,149,625
1886	2,533,807	318,736	2,852,543
1887	2,451,860	490,767	2,942,627
1888	2,461,675	166,811	2,628,486

These figures show two very remarkable results attained during recent years; in the first place, a considerable diminution in the number of sleepers consumed, a diminution which is due to the care taken by the companies for the maintenance of their roads, to the new methods adopted for the replacing of the sleepers, and to the preparation of all the varieties by means of creosote; and, in the second place, an enormous diminution in the use of sleepers of foreign production.

CHAPTER XXIV.

ACCESSORY PRODUCTS—GUMS, THE WORK OF M. FREMY—RESINS—BARKS—TAN—APPLICATIONS OF CORK.

THE products other than wood furnished by trees are numerous and important. These may be quoted: gums, barks, certain oils, sap, fruit, leaves, and different agricultural products.

The principal of these only will be dealt with.

GUMS.

Certain neutral substances soluble in water, swelling considerably in this liquid, insoluble in alcohol and ether, and always uncrystallisable, are designated under the name gums.

Gums can be divided into three varieties: *arabine*, *cerasine*, and *bassarine*.

Arabine $C_{12}H_{11}O_{11}$.—Of all the gums this is the most important. It appears in irregular fragments, upon breaking, brilliant and conchoidal. Inodorous, without savour, this substance is soluble in water, but insoluble in alcohol and ether. Its specific gravity is 1·4.

In heating arabine at 130°, it is made to lose an equivalent of water; it is transformed to an isomer of starch.

Acids transform arabine into dextrine, then into glucose. By operating at a high temperature, a mixture of acetate, formiate, and metacetonate of potash is obtained with potash.

If distilled with lime, a mixture of acetone and metacetone is produced.

The arabine solution rotates to the left the polarised light; if it is evaporated, a brilliant varnish is obtained.

Arabine is precipitated from its solution by sulphate of peroxide of iron, nitrate of mercury, subnitrate and subacetate of lead.

Combinations of arabine with alkalies and oxides of the alkaline-earths are soluble in water and precipitated by alcohol.

Arabinate of lead is a curdled precipitate, insoluble in water, which can be obtained by one of the three following reactions:—

(1) By precipitating subnitrate or subacetate of lead by a solution of gum.

(2) By pouring the nitrate of lead into a gummy solution, with a little ammonia added.

(3) By digesting protoxide of lead with a solution of gum.

Arabinate of copper is amorphous; it is blue in colour. If its solution is boiled in water, no deposit of red copper oxide is obtained: this is the characteristic reaction clearly distinguishing gum from dextrine.

Cerasine, Bassarine.—The first is of but little importance, and is imperfectly known.

Bassarine is found in abundance in gum tragacanth. Treated with water, it forms a mucilage by swelling considerably. Submitted to the action of boiling water, it becomes converted into arabine; an addition of nitric acid gives birth to mucilaginous acid.

Gum Arabic.

Gum arabic is almost pure arabine. This product trickles naturally from several varieties of acacia.

The *Acacia vera* grows in Arabia and throughout the whole of Africa; this is it which produces the true gum arabic.

The *Acacia arabica* gives Indian gum.

The *Acacia Adansonii* produces in Senegal a rather abundant red gum.

The *Acacia verek* furnishes the largest part of the gum from Senegal.

The *Acacia gummifera* provides the gum of Barbary.

True Arabic Gum.—This appears in small white and transparent drops, cracking easily upon exposure to the air.

Senegal Gum.—There are two kinds of this. The first—that of the *shallow river*—is the most valuable. When it is well sorted, it is composed either of dry, hard, round, or oval drops, wrinkled upon the exterior, vitreous on the interior, and of a pale yellowish colour, or of larger, spherical pieces, not so dry and transparent, and of a colour bordering on red.

This gum is quite soluble in water. Oxalate of ammonia abundantly thickens this solution, which is entirely precipitated by alcohol.

The second gum, called *high river*, occurs in less regular pieces, often angulous and brilliant.

Pelliculated, *green*, *shining*, and *mammilated* gums may be cited as belonging to this species, and then the different gums of France, Barbary, Sicily, India, Australia, the Cape, Madagascar, Chile, etc.

Cherry-Tree Gum.

This gum is extracted from our fruit-trees—cherry, plum, and apricot. It oozes spontaneously from the trunk and branches of trees which are old. At first liquid and colourless, it becomes solidified and brown upon contact with the air. Water dissolves it in part only, and it forms a thick mucilage.

Gum Tragacanth.

This is drawn from a shrub (*Astragalus verus*) growing in the north of Persia and Asia Minor. It is a white or yellow substance, slightly soluble in water, in which it swells considerably, forming a thick mucilage.

THE WORK OF M. FREMY.

We will resume, according to the work of M. Fremy, the principal chemical points which have been observed in the gums:—

(1) Gum arabic is not a neutral direct principle. It should be considered as the result of combination of lime with very weak acid, soluble in water, called *gummic* acid.

(2) This acid may experience isomeric modification and become insoluble either by the action of heat or under the influence of concentrated sulphuric acid. The name *metagummic* acid has been given to this insoluble compound.

(3) The bases, and especially lime, transform this insoluble acid into gummate of lime, which presents all the chemical characteristics of gum arabic.

(4) The soluble calcareous compound forming ordinary gum can also experience by heat isomeric modification, and become transformed into an insoluble body, which is metagummate of lime. This insoluble substance again becomes soluble by the action of boiling water or under the influence of vegetation. It exists in the vegetable organisation, and it is this which forms the gelatinous part of certain gums, like that of the cherry-tree; it is found in the woody tissue and in the fleshy pericarp of some fruits. Its isomeric modification account for the production of soluble gums.

(5) There exist in the vegetable organisation several insoluble

gelatinous bodies, which, by their transformations, produce different gums. Thus, the insoluble part of the gum of Bassora, modified by the action of alkalies, gives a gum which must not be confounded with gum arabic; the reagents establish between these two bodies marked differences.

It is thought that gum is due to a malady of the tree arising from different causes, which all have for their effect the accumulating upon the same places of a too considerable quantity of sap. It originates from too abundant nutrition of the tissues. When the latter receive too much sugar, the young cells of the generating layer are reabsorbed. Air-cells full of liquid result, to which are mixed the contents of the dissolved cells, the membranes not completely liquefied, and cells entirely detached from the disaggregated periphery of these incidental cavities.

At this time no trace of gum has appeared. This substance is but rarely or never discovered in air-cells surrounded by very young tissues. It is usually only rather a long time after reabsorption that the gum begins to present itself. It makes its first appearance at the periphery of the lacunæ, in the form of colourless productions, often mammilated, of gelatinous appearance, which fill these lacunæ progressively.

The sojourn of the gum in the bark, by maintaining constant dampness, becomes very pernicious; fermentation is set up, the liquids become acidified, and contribute powerfully towards the destruction of the tissues in which they are spread.

RESINS.

These are inflammable matters more or less solid or viscous which flow from certain trees. They are distinguished from gums in so far that they are not soluble in water, which makes them very combustible. They can be classed in three categories: the *liquid*, *solid*, and *gum resins.*

The liquid resins, or balsams, contain enough essential oil to remain liquid: these are *turpentine*, *copaiba balsam*, *Mecca balsam*, and *benzoin.*

The solid resins comprise *animi resin*, *colophony*, *gum lac*, *sandarac*, etc.

The most important gum resins are *copal*, *elemi resin*, *gamboge*, *gum ammoniac*, etc.

The following are the principal resins:—

American gomart resin (*Bursera gummifera*), coming from Martinique and Guadeloupe, employed in felting.

Carnauba resin, from Guiana.

Mani resin (*Moronbea coccinea*), abounding in Guiana, employed to caulk canoes and fix the iron of the poles.

Sandarac, extracted in large quantity in the colony of Victoria from

Callitris verrucosa. It is a resin of palish yellow colour, insoluble in water, but soluble in alcohol. It is composed of three acid resins.

Zanzibar copal: this country is capable of providing more than a million kilogrammes of it annually.

The gum copal of Gabon (*Guibourtia*), which is inferior in quality to that of Zanzibar, and which the natives gather in the sands of large plains, where forests were undoubtedly found, and to-day destroyed by fire.

The resin of Ocoumé, produced from a tree of the terebinthaceous family, which is very common in Gaboon, where it serves for lighting; this resin can be employed in medicine and in the felting of hats.

Orient copal (*Valeria indica*), coming from the Indies.

Kauri resin (*Dammara ovata*), issuing from New Caledonia.

The resin of *Tabernæmontana macrophylle*, also produced by this latter colony.

Dhoona resin, extracted by incision from the *Shorea robusta*, very extensive trees in the Indies. It costs about fourpence the kilogramme.

Gum-lac, produced by the *Coccus lacca*, issuing from the Indian provinces Ramree, Akyab, Leydomey, Neypore, Pegu, and forming an object of considerable exportation.

Black lac, extracted from the *Melanorrhœa usitatissima*, forming a highly esteemed product, whose value, in the Indies, varies from 80 to 180 francs the 100 kilos., according to quality.

The resin of the black pine (*Pinus austriaca*), a variety of tree seldom met with but in the large forests of lower Austria. This resin is of superior quality.

Australian kino, extracted from different varieties of trees of the *Eucalyptus* family, in the colony of Victoria.

The resin of the *Pinus pinaster*, collected in Italy.

Finally, the resins of the maritime pine, gathered in France, comprising the following specimens:—

(1) *Soft resin*, or pasty gum, semi-liquid, trickling along the grooves made in the tree and gathered into earthen recipients.

(2) *White resin*, or concrete gum adhering to the tree.

(3) *Barras*, or concrete gum, not so pure as the preceding.

The substance derived immediately from gum resins is turpentine, employed in perfumery and varnish-making. It is the soft resin submitted to the action of the sun which provides, by simple decantation, the virgin turpentine. A superior product is obtained by collecting the oozing which operates through the staves of casks filled with soft gum. This produce is termed Venice pitch.

The distillation of the gum resins, which is done at a moderate heat in coppers with an addition of water, gives 16 per cent. of turpentine. This distillation, moreover, provides 75 per cent. of rosin, 2 per cent. of colophony, and 7 per cent. of pitch.

The pitch, pyrogeneous oils, and tar, which are also prepared in the waste lands of Gascony, are obtained by direct distillation of the *débris* of manipulation.

The rosin also serves to make lubricants for greasing the axles of carriages or machines. Candles are also made from it, and are principally sold in Brittany.

BALSAMS.

We will resume, with regard to the interesting part of the subject now engaging our attention, the remarkable work published by M. Fremy in reference to balsams.

These resinous substances are not always characterised, as has for some time been thought, by the presence of benzoic acid, for two very distinct varieties of balsams exist, namely—

(1) Balsams with cinnamic acid base.

(2) Balsams with benzoic acid base.

Balsams exposed to the air become thickened by degrees, being often even completely solidified. They may be considered as mixtures of essential oil, different resinous matters, and cinnamic or benzoic acid.

Amongst the pure benzoic-acid balsams may be mentioned benzoin. Balsam of Peru contains, on the other hand, only cinnamic acid.

Balsam of Peru.

This is found in commerce in two conditions—liquid and solid.

Liquid balsam of Peru contains two interesting substances: the liquid one has been called *cinnamine*, and the other, which is solid and crystallisable, has been termed *metacinnamine*.

In order to obtain pure cinnamine, recourse can be had to one or the other of the following methods:—

(1) A concentrated solution of potash is added to the liquid balsam of Peru, and it is briskly agitated. A brown magma is formed which is a mixture of resinate and cinnamate of potash, insoluble in cinnamine, which is thus found isolated and is immediately decanted.

(2) The balsam of Peru is dissolved in alcohol at 36°. An alcoholic solution of potash is added to the liquor; the cinnamate of potash remains dissolved in the alcohol, whilst the resinate of potash is pre-

cipitated. The alcoholic liquor treated with water allows the cinnamine to precipitate.

The cinnamine is liquid, slightly coloured yellow; it boils at 305°. Its odour is weak and agreeable; very slightly soluble in water, but very soluble in alcohol and ether. Its formula is $C_{54}H_{26}O_8$.

Submitted to the action of potash, this substance undergoes a sort of saponification, and becomes transformed into cinnamate of potash, by creating *peruvine*, which is a neutral body.

Sulphuric acid transforms cinnamine even cold into another resinous substance $C_{54}H_{30}O_{12}$, which only differs by four equivalents of water fixed in this reaction.

Nitric acid transforms cinnamine into a yellow resin, producing at the same time a certain quantity of essence of bitter almonds. Placed in a receiver full of oxygen, the cinnamine absorbs this gas, and becomes transformed into cinnamic acid.

Peruvine has for its formula $C_{18}H_{12}O_2$; it contains four equivalents of hydrogen more than hydride of cinnamyle. It is liquid, and boils at 180°; lighter than water, very volatile, and slightly soluble in water, it is very soluble in alcohol and ether. Its odour is agreeable and aromatic. Nitric acid transforms it into hydride of benzoin.

Metacinnamine is a crystalline substance met with in some specimens of balsam of Peru; it is an isomeric matter of hydride of cinnamyle. Insoluble in water, soluble in all proportions in alcohol and ether, it is easily transformed by potash into cinnamate of potash. Gaseous chlorine attacks it and gives chloride of cinnamyle.

Balsam of Tolu.

This is extracted by incision of the bark of the *Toluifera balsamum*, met with in South America. This balsam is yellow, and its balsamic odour is agreeable. Sometimes viscous like turpentine, sometimes hard like benzoin, it contains a resinous substance appearing to be a mixture of several resins.

The free acid of the balsam of Tolu is pure cinnamic acid.

The resinous part is formed of two distinct resins: one (α) is very soluble in cold alcohol, the other (β) being slightly only soluble.

Resin (α) $C_{36}H_{18}O_8$ is obtained by draining the balsam through cold alcohol, then evaporating it. It is brown, brittle, soluble in ether and alkalies.

Resin (β) $C_{36}H_{20}O_{10}$, which is insoluble in alcohol, is very brittle, and is easily dissolved in potash.

These resins, distilled with precaution in the presence of caustic soda, provide toluene $C_{14}H_8$. Treated with nitric acid, they give essence of bitter almonds.

Benzoin.

This balsam is extracted, by incision, from a variety of styrax, common in Sumatra and the kingdom of Siam. It contains several different resins, benzoic acid, and an essential oil of agreeable odour analogous to the hydride of benzoyle, forming by oxidation benzoic acid.

Benzoin submitted to distillation gives rise to several oils, amongst which benzoic ether is found. This ether probably comes from the sugar of the plant which, by its fermentation in the presence of benzoic acid, has produced benzoic ether. The products of this distillation contain, moreover, phenic acid.

The action of nitric acid upon benzoic gives derivatives belonging to the benzoic and phenic series. Sulphuric acid produces a conjugated acid and two resins.

Benzoin serves in the preparation of benzoic acid; it enters into the composition of the balsam of the commander.

Turpentines.

These are natural compounds formed by the mixture of an acid resin of soft consistency with an essential oil. The majority come from the Coniferæ family, the principal being—

Bordeaux turpentine, belonging to the *Pinus maritima*; it is of disagreeable odour, and of sharp and bitter savour.

Venice pitch, coming from the *Pinus picea*; it is transparent, and its savour is bitter.

Ordinary or *Vosges turpentine* trickles from the *Pinus larix*.

Boston turpentine comes from the *Pinus Australis*.

American turpentine issues from the *Pinus strobus*.

Hungarian turpentine from the *Pinus mughus*.

Canadian balsam comes from the *Abies balsamea*; it is almost colourless and of bitter savour.

Mecca balsam trickles from the *Balsamodendron gileadense* and *opobalsamum*.

Chio turpentine is produced by *Pistacia terebenthus*; it is of greenish-yellow colour, of agreeable odour, and of perfumed savour.

Copaiba balsam comes from *Copaifera officinalis*.

ORDINARY TURPENTINE.

In order to extract this substance from the *Pinus larix* which produces it, a band of bark 12 cms. broad by 30 high is removed, a little distance from the ground. An incision of some millimetres is made, and a small earthen pan is placed underneath, into which the turpentine flows. When the sprouting is stopped, a fresh incision is made above the first one, and so on, rising up to a height of 16 ft.

A tree in the Landes lasts for seventy-five years, giving each year about 4 kilogs. of turpentine. The turpentine is always mixed with woody matters; it is purified by exposing it to the sun and water vapour, and decanting it when it has become liquid. The solid part is distilled in cast-iron or copper apparatuses; it is this which gives the essence. For 100 of turpentine, 12 of essence and 88 of resinous matter, known as rosin or colophony. When the wood is drained it is cut into pieces, and in distilling it a tar is obtained which, mixed with pitch, is useful in the caulking of ships.

COLOPHONY OR ROSIN.

This resin is not a pure direct principle; it contains sometimes two, sometimes three isomeric acids, bearing the names of *pinic*, *pimaric*, and *sylvic* acids.

The *pinic acid* constitutes the amorphous resin contained in colophony; it is very analogous to sylvic acid.

In order to prepare it the colophony is treated cold by alcohol at 72°; then the acetate of copper is poured into the solution. Pinate of copper is precipitated; it is collected on a filter, and afterwards decomposed by a mineral acid, after having been carefully washed.

Sylvic acid is insoluble in water, and soluble in ether, concentrated acetic acid, and oil of naphtha. It dissolves towards 125°, and combines with alkalies.

If a solution of sylvic acid is left to settle in alcohol, a deposit of *oxysylvic* acid is obtained.

The sylvic acid is obtained by draining warm through alcohol the residues of the pinic acid preparation. The alcoholic extract gives, by the cooling of the rhomboidal sheets, sylvic acid.

Turpentine, which flows from the *Pinus maritima*, contains instead of pinic acid, another acid, namely, *pimaric acid*. This crystallises in straight prisms with rectangular base; soluble in boiling alcohol and ether, it also dissolves towards 125°.

Submitted to distillation, pimaric acid gives sylvic acid and *pimarone* $C_{40}H_{28}O_2$.

When this acid is treated with nitric acid, *azomaric acid* is produced, which is yellow, amorphous, resinous, and insoluble, its formula being $C_{40}H_{26}(AzO_4)_2O_8$. Azomaric acid is bibasic; its salt, which is ammoniacal and very soluble, dries in transparent plates, of an orange-red colour.

Distillation decomposes colophony; 1400 kilogs. of rosin give, when distilled, 40 kilogs. of essential oil, 400 kilogs. of slightly volatile oil, and 900 kilogs. of tar.

The products from this distillation contain four different carbides of hydrogen—*retinaphtha*, $C_{14}H_8$; *retinyle*, $C_{10}H_{12}$; *retinole*, $C_{32}H_{16}$; and the isomeric metanaphthaline of naphthaline. The mixture of these different carbides bears the name oil of resin.

The part of this oil which boils between 108° and 150° is a mixture of retinaphthane and retinyle, which is employed in commerce as a substitute for turpentine in certain of its applications.

The second portion of the oil, boiling towards 240°, is retinole, and is useful in the making of certain printing inks.

Mixed with lime, it forms a kind of tallow known in commerce under the name *black tallow*.

Among the gases evolved during distillation of colophony, ethylene and butylene may be mentioned.

The resin oils are employed in the making of resin gas, which possesses a bright and very intense power.

M. Fremy, by distilling colophony with lime, obtained two liquid substances: one—*resinone*—boils at 78°; the other—*resineone*—at 148°. Carbonic acid is besides formed, remaining joined to the lime.

ELEMI.

This name has been given to several yellow and odorous resins issuing from the Terebinthaceæ family. The elemi of commerce comprises:

(1) Crystallisable resin.

(2) A resinous, amorphous substance $C_{40}H_{30}O_4$.

(3) Variable quantities of isomeric essential oils, with essence of turpentine.

Crystallisable resin is white, soluble in concentrated and boiling alcohol. Elemi contains 30 per cent. of it. The amorphous resinous substance, which is very soluble in cold alcohol, reddens litmus paper.

RESIN OF THE TAR-TREE.

This matter, issuing from the *Canarium album*, is grey, glutinous, and of agreeable odour ; it contains four different substances:

(1) *Amyrine*, a resinous matter insoluble in alcohol, slightly so in cold alcohol, and very soluble in boiling alcohol and ether.

(2) *Breine*, which is soluble in alcohol and ether, insoluble in water, fusible towards 190°, and crystallising in oblique rhomboidal prisms.

(3) *Bryoidine*, a neuter and bitter resin, crystallising in silky fibres, fusible towards 140°, volatile, and very soluble in alcohol and ether.

(4) *Breidine*, crystallising in transparent rhomboidal prisms, and soluble in water, alcohol, and ether.

COPAL RESIN.

This is the most important of the gum resins; it is useful in the preparation of hard varnishes of good quality. It is collected upon the *Hymenæa verrucosa*. Very hard, almost colourless, with neither odour nor savour, it has for its density 1·139. Almost insoluble in anhydrous alcohol, it finishes by being dissolved in ordinary boiling alcohol; the ether swells this matter, and afterwards dissolves it.

Copal resin, brayed in the air, then dried in a stove for a month, absorbs the oxygen of the air, and becomes very soluble in ether and even alcohol. This property is utilised for its industrial employment.

Courbaril resin, or tender copal of India, comes from the *Hymenæa courbaril*; it is met with in white globular sheets, fusible at 140°, soluble, cold, in essence of turpentine and almost insoluble in anhydrous alcohol.

A tender copal, of pale yellow colour, is imported from America, whose brilliancy is vitreous, colour agreeable, and which is soluble in boiling alcohol.

Several oxygenated essential oils, notably essence of lavender, rosemary, and peppermint, possess the property of softening the copal at the ordinary temperature and of incompletely dissolving at a high temperature.

Distillation of copal produces an oil having as its composition $C_{20}H_{16}$, and boiling at 165°. This oil, whose density is equal to 0·951, dissolves caoutchouc and resembles the oil of yellow amber.

GUAIACUM.

This resin is of greenish brown, friable, soluble in alcohol, ether, and essence of turpentine. Its odour is similar to that of benzoin, and its savour is bitter.

Nitric acid dissolves guaiacum root, and colours green; water determines in this liquor the formation of a green precipitate, and the remainder of the solution becomes blue. A larger quantity of water browns the liquor, and turns the colour of the precipitate, which becomes blue.

Guaiacum resin is easily soluble in potash and sulphuric acid. Subacetate of lead precipitates it completely from its alcoholic solution.

The sulphuric solution of guaiacum resin is red, and water being added throws down a violet precipitate.

Guaiacum resin has for its characteristic property the colouring blue under the influence of the violet rays of the spectrum and of becoming discoloured by red rays. The same phenomenon is immediately produced by chlorine.

Tincture of guaiacum is blued by perchloride of iron; this coloration passes to violet under the influence of hyposulphite of soda, then afterwards totally disappears.

The vapours of nitric acid colour the guaiacum tincture blue, and this very appreciable reaction may reveal the presence of nitric acid.

BARKS—FLAYING.

Those forest varieties whose bark is utilised by commerce are rather numerous. The following may be mentioned: the oak, cherry, wild cherry, birch, alder, linden, elm, and pitch pine. These barks are employed in the tanning of leather, which subject will be touched upon; the two last serve principally in the preparation of Russian leathers.

Moreover, the bark of the lime and elm is useful in the making of mats, carpets, and especially ropes. That of the birch and wild cherry-tree is employed for snuff-boxes, soles of shoes, and the harness of horses.

All these products present but little importance if compared with those given by the oak, furnishing barks fit for tannage and cork-making.

It is recognised to be time to proceed to the flaying when the buds begin to swell, to open and allow the first leaves to appear. Strictly, the operation can be continued until complete fading of the leaves; but the

bark is not then detached so easily, it is not so rich in tannin, and consequently loses its value.

For a long time, flaying was proceeded with in a very primitive way, consisting of making circular incisions on the trunk of the tree, and afterwards detaching the bark by the aid of a spatula. The trees are sometimes stripped as they stand, and sometimes after they are felled.

Whichever is done, this mode of procedure is primitive, and mechanical flaying has been sought after, especially on a large scale.

M. Maître, relying upon the action of damp and heat upon woody layers, proposed steam so as to effect this kind of work in all seasons.

The appliance at first employed with this object is very simple. It consists in a sheet-iron vertical cylinder divided into two compartments. In the lower compartment there is a grate; the upper one is simply a copper.

There is a cover on this copper pierced by two holes, and furnished with a sheet-iron tube, so that the vapour produced can penetrate alternately into the compartments or casks where the wood is placed that is to be stripped. At the end of forty or fifty minutes' heating the timber is sufficiently steamed to be submitted to the peeling process.

This wood, in fact, closed in the compartments, is heated by contact with the vapour; the dampness distends the pores, and, at a given time, it has all the properties of wood in good sap, and can be worked without loss of time and without fear of producing waste.

This first apparatus has been perfected in the following manner:—The grate is arranged with a return of the flame. Above the copper a wooden chest is established furnished with sheet-iron, and divided into two compartments, each of which is capable of containing half a stère of wood. The chest is separated from the recipient by a kind of framework, and the whole appliance is transportable.

So as to be able, in case of necessity, to make a single compartment work, a register of galvanised sheet-iron has been arranged in the lower part of the chest, with a piece of iron as a handle, which permits of opening or intercepting alternately all communication of the steam between the copper or one and the other compartment. A double cylinder clamping the chimney receives the water destined for alimentation. The water is heated by the smoke and gases coming out of the chimney. It is diverted into the copper by means of a cock in a continuous manner; it is renewed from hour to hour by the aid of a pump. The first charge lasts about half an hour; the following ones not quite so long.

The bark thus obtained leaves nothing to be desired from a physical

point of view: its quality is excellent, for the steam, in these conditions, cannot change the tannic principles contained in the vegetable fibres.

With this system felled timber can be barked beyond the time of the sap and a long time after felling, which could not be done by ordinary processes.

TANNING MATERIALS.

The tanning materials are extracted from the vegetable kingdom, and principally from the barks of certain trees. There is a considerable number of them; but only the most important will occupy our attention.

The barks employed in European tanneries are those of the ordinary oak, the cork-tree, quebracho, chestnut, pine, fir, birch, and alder.

Algeria produces numerous kinds of barks, employed by the Arabs in the preparation of their leathers, and notably of the different sumacs extracted from the *Rhus coriaria*, *Rhus glabra*, *Rhus pentaphylla*, a large quantity of oaks, etc. The exploitation of these barks is carried out on a large scale, giving rise to an important exportation.

A tannate matter which is the object of a large trade in Asia is the *areca nut*, also called betel-nut.

This nut contains a deal of tannin; it is the fruit of an elegant palm-tree met with also in the French colonies of Martinique and Guadeloupe.

Acacia barks can also be ranged amongst the tanning matters. The principal are those of the *Acacia arabica*, called by the Indians Babool barks; those of the *Acacia catechu* and *Acacia farnesiana*; and finally, those of the *Acacia horrida*, employed at the Cape of Good Hope.

The pods of the *Acacia nilotica*, called "nib-nib," also serve in Nubia for leather preparation.

The barks of the *Acacia dealbata* and the *Acacia melanoxylon* are largely used for tannage in Tasmania, where these trees are numerous and attain a good height.

The barks of the Antilles oak (*Catalpa longissima*), the mango-tree (*Mangifera indica*), the conocarpes (*Conocarpus arborea*), the *Bucida*, the badamier (*Terminalia catalpa*), the barks and leaves of the mangrove (*Rhizophora mangle*), and the barks of tan wood (*Malpighia spicata*) are also tanning materials collected in Martinique and Guiana.

In British Guiana, the barks of the *Mora excelsa*, the *Spondias lutea*, and different *Nectandra* are employed.

Reunion produces as tanning materials the bark of the black wood (*Acacia lebbek*), the flao (*Casuarina equisetifolia*), the bancoulier (*Aleurites triloba*), matting wood (*Imbricaria maxima*), and false benzoin.

The name "Algoraba" is given to the seeds of the *Prosapis palida*,

which are rich in tannin and largely employed in the tanning of skins at Valparaiso.

The fruit of the citrine mirobolan (*Terminalia chebula*) and of the *Terminalia ballerica* is also the object of an important trade for the preparation of leathers in India.

Dividivi or dibi-dibi is the seed of the *Cæsalpina coriaria*, which is the object of considerable commerce at Maracaibe and Savanille.

Kino is an exudation largely employed for tannage in Bengal; it is produced by the *Sterocarpus marsupium*.

A kino is also known in Africa produced by the *Sterocarpus erinaceus*. At Gaboon an excellent kino is drawn from the sap of a *Myristica* called by the natives *combo*.

OAK BARKS.

This is the most important of the tanning matters.

Tan is a product useful for the transforming of skin into leather. Tannin, properly so called, is an essential principle of the tan, and is met with in the majority of the vegetable astringent substances, principally in the barks of oaks, and especially in the different excrescences which are formed as a result of the attacks of insects upon the young branches of several varieties of oaks, and which are called oak-galls.

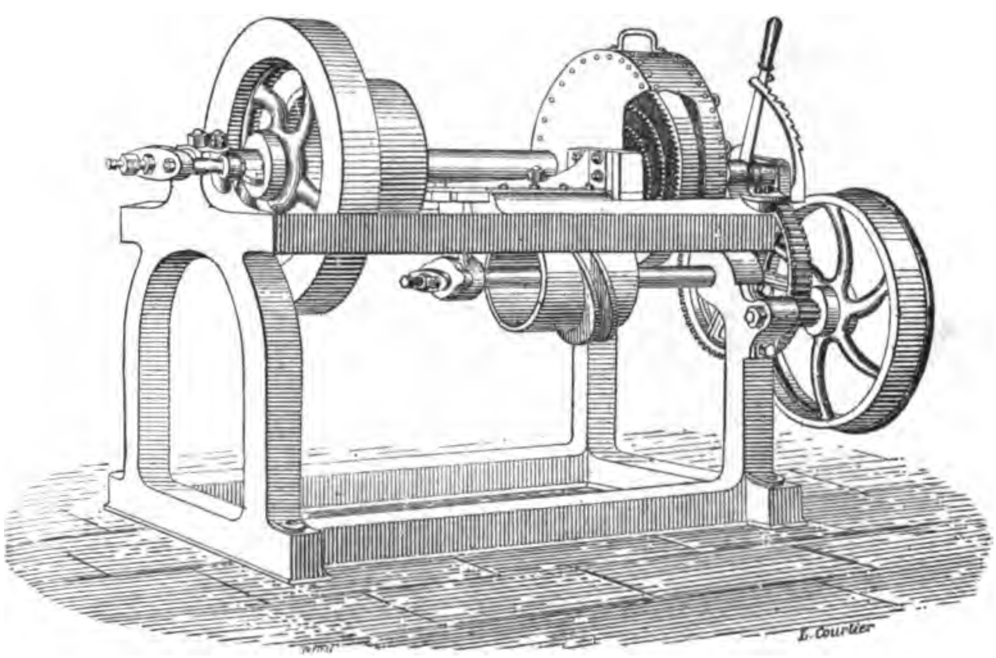


FIG. 167.

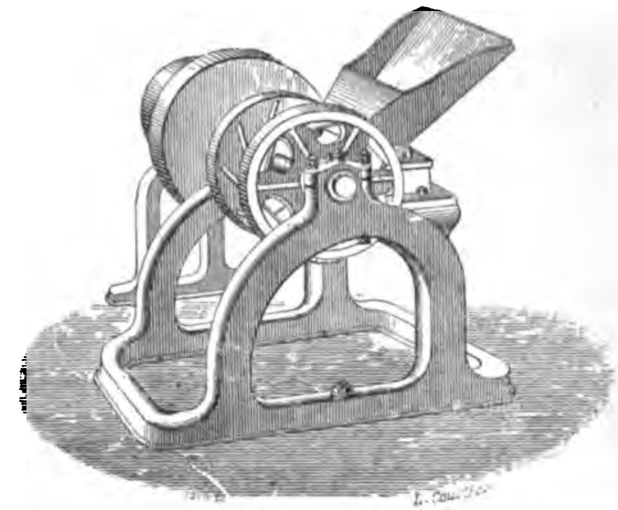


FIG. 168.

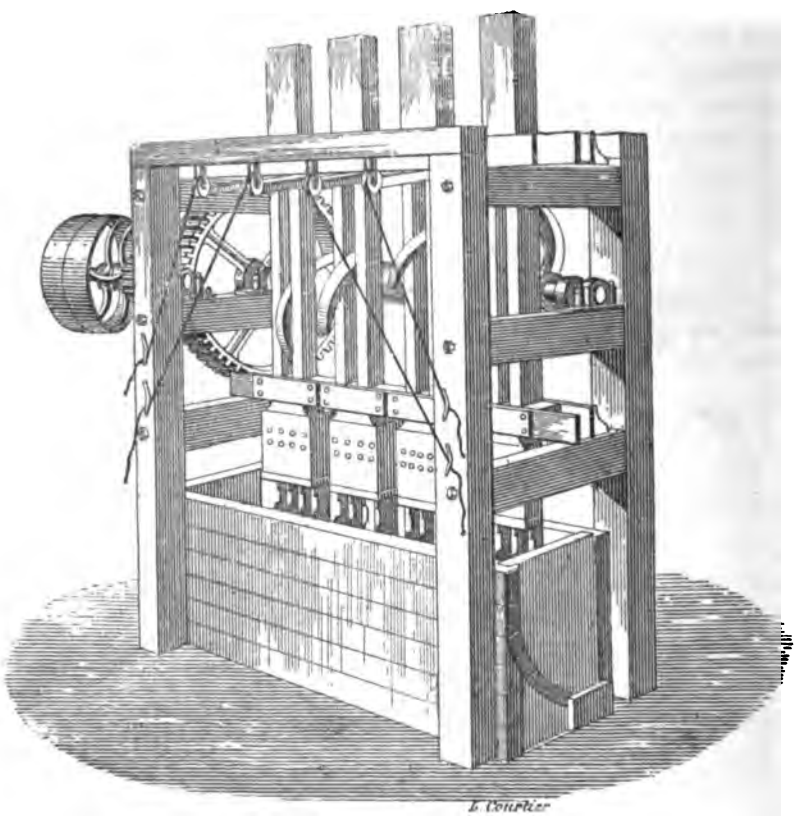


FIG. 169.

When the bark of the oak is ground it is termed *tan*.

In order to bring the bark to a suitable condition for its utilisation in tanning pits it has to undergo several preparations of pounding and trituration, which are generally carried out by the aid of machines, represented by Figs. 167, 168, 169, 170, and 171.

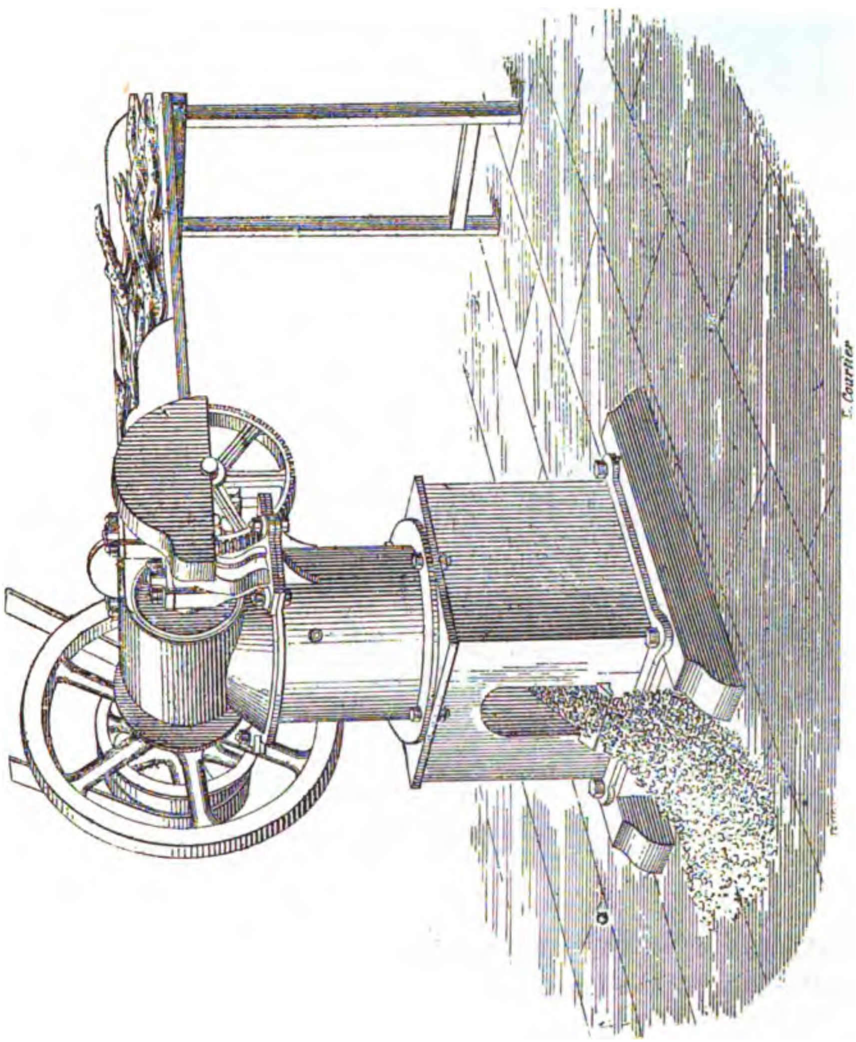


Fig. 170.

These illustrations explain themselves, and enumeration merely is necessary.

Fig. 167. Machine for pounding wood and bark.

Fig. 168. Machine for triturating tanning timber; the force employed is about four horse-power for a production of 350 kilogs. the hour.

Fig. 169. Tanning pestles; force employed: one horse-power per pestle.
Fig. 170. Tanning mill.
Fig. 171. Tanning mill; nut system.

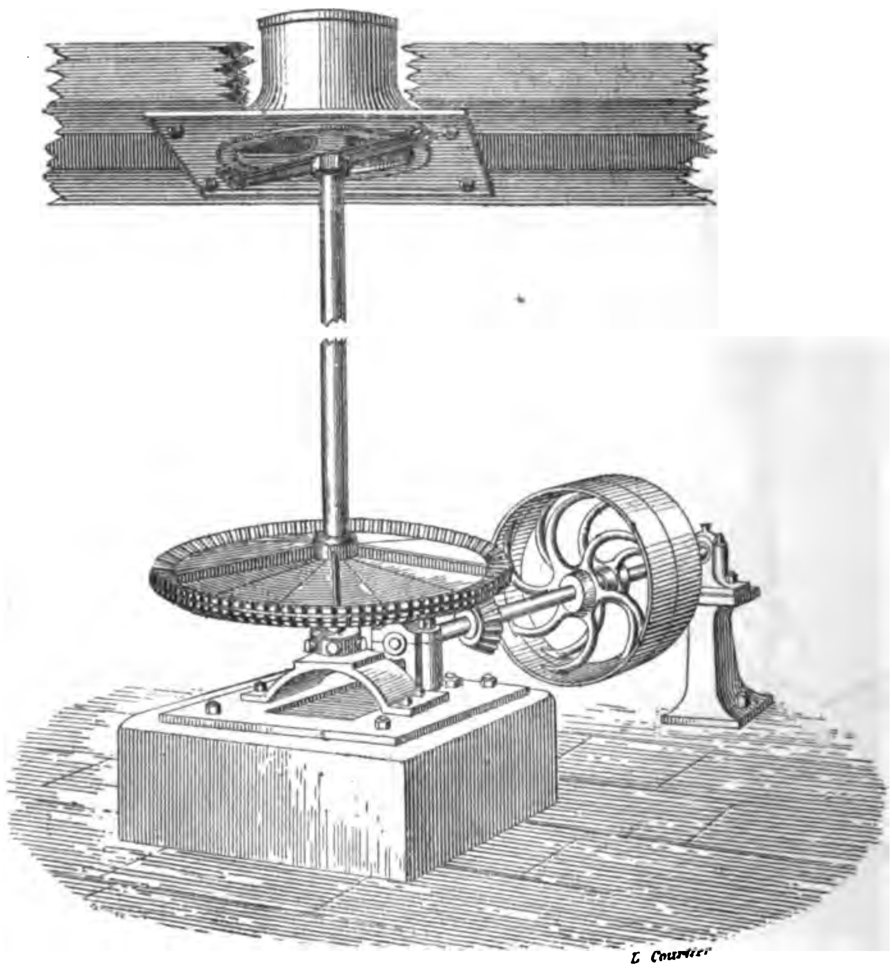


Fig. 171.

The bark of the oak ground, or the *tan*, contains, on an average, the following quantities of tannin:—

	Tannin per cent.	Age of Trunks.
Wrinkled bark, with external cortical layer	11·0	41 to 52
Layer of liber of the old bark	14·3	41 ,, 53
Internal layer	13·2	41 ,, 53
External and internal layers	11·7	41 ,, 53
Layer of liber and external layer	13·9	41 ,, 53
Internal layer	13·9	14 ,, 15
Internal layer	15·8	2 ,, 7

In the United States tan is extracted from four different kinds of oak.

The first is Spanish oak, known under the name of red oak. Its bark, which is thick, black, and with deep burrows, is prepared for coarse leathers, which it renders more supple and of a better colour.

The second is the *rock chestnut*, which is very abundant in elevated districts. Its bark is thick, hard, and has deep burrows. It differs from other barks in that the epidermis contains more tannin, which, in the other varieties, is found principally under the interior layers.

Quercitron, or *black oak*, follows, the bark of which is scarcely serrated, bitter, and deeply furrowed; it is of a rather pronounced brown or black colour. Quercitron is rich in tannin, and is commonly employed. Finally, the American tanners also employ the barks of scarlet (holm-oak or kermes oak), grey, and evergreen oaks.

In Europe and Northern Africa the barks of the cork-tree, zeen, evergreen, and kermes oaks are employed for tan-producing.

Tan of the Cork-Tree.

The tanning bark of the cork-tree is formed by the interior portion of the cortical system comprised between the sapwood and the suberose portion. It is only collected on old trees or plants of medium age which have not been barked previously. Its thickness varies from 10 to 50 mms. It comprises the liber and cellular envelope, whose external portion is constituted by strongly incrustated cells forming a tissue of ochreous-red colour, in which the major part of the tannin is found.

In practice, the abundance of this product is estimated by the intensity of the red coloration of the bark.

In general, the stronger the thickness of the exterior part of the cellular envelope, the more tannic acid is there.

Analyses of barks considered from a commercial point of view as moderately rich have given 19 per cent. of tannin.

The exploitation of the tanning bark in cork-tree forests is carried out on the old varieties, whose age or state of vegetation does not permit of stripping. These trees intended to be felled are left on one side at the time of stripping, then sold each year.

Gathering takes place from the 25th of May to the 1st of September each year. The trees are felled, the cork is removed, and afterwards the tanning bark. After having been detached from the tree in pieces cut as regularly as possible, the bark is stretched in the sun. The duration of desiccation varies from three to five days. This is the most delicate part of the operation; it is necessary to keep the bark from the action

of dampness, for wetted tan becomes black. It is covered by mouldiness, which may communicate with the healthy barks and deteriorate them by decomposing the tannic acid which they contain.

The blackened bark loses a considerable part of its value, and depreciates the merchandise in which it is met with.

Tanning barks of Algeria and Tunis are exported. The sale price at Bona, which was from 11 francs the metric quintal in 1866, reached 18 francs in 1888.

The expenses of exploitation and transport in Tunis may be estimated as follows:—

	Francs.
For bark transported to Bona:	
Exploitation in the forest; putting it into sacks	3·50
Cost of sacks and string	0·20
Unlading in forests, to collect the bark	0·15
Transport by beasts of burden to an average distance of, roughly, 20 miles	2·75
Clearing of cuttings at 50 centimes per tree	0·30
Average purchase price	6·15
General expenses	
Net total	13·05

The tanning bark of the cork-tree is exported to Italy, Portugal, and England. At equal weight it contains more tannin than that of other oaks, excepting the root of the kermes.

Leathers treated with this bark have their pores more compact, are firmer, and not so changeable by damp. They are more of a rose colour, but this excess of coloration has no importance, for they are only employed in the making of soles of boots.

It is admitted in Italy that tannage with the bark of the green oak or oaks with caducous leaves requires a duration of twelve to fifteen months, whilst ten suffice when the bark of the cork-tree is used.

Italy consumes annually 8000 metric quintals of tanning bark of the cork-tree, Portugal 20,000, and Ireland about 10,000.

The countries of production are the following, which provided in 1888—

	Quintals.
Sardinia	45,000
Spain	5,000
Algeria	45,000
Tunis	45,000
	140,000

The Sardinian forests are getting exhausted, but those of Spain, Algeria, and especially Tunis can, for many years to come, be sufficient for the greater part of the consumption.

In Tunis the results of the four last years are the following:—

	1885.	1886.	1887.	1888.
Number of trees cultivated	21,406	8,039	23,450	21,855
Quintals of bark gathered	31,838	10,874	36,446	42,605
Average yield per tree	148 k.	135 k.	155 k.	195 k.
Maximum yield	257	231	307	320
Minimum yield	81	110	71	125
Total sale price	158,706 f.	64,386 f.	240,189 f.	308,080 f.
Average sale price per tree	7 f. 40 c.	8 f.	10 f. 20 c.	14 f.
Maximum ,, ,,	10 f. 15 c.	10 f.	14 f.	19 f.
Minimum ,, ,,	4 f. 75 c.	7 f.	5 f. 30 c.	7 f. 40 c.
Sale price per metric quintal on the spot	5 f.	5 f. 90 c.	6 f. 60 c.	7 f. 20 c.

Tan of the Kermes Oak.

The bark of this oak is very rich in tannin.

The following figures can, on an average, be relied on:—

Bark of young oak	11 per cent.
Bark of oak of average age	15 ,,
Bark of roots	22 ,,

The stems are generally too small to be exploited. Only the bark of roots is collected, which bears, in commerce, the name *garouille*. The consumption of garouille is about 25,000 metric quintals yearly.

The regions where it is employed are Provence, which lays in a supply on the spot; England, which purchases 10,000 quintals of it; Belgium and the North of France, which import 10,000 quintals through Antwerp and Havre.

This tanning matter is only employed by tanners making heavy leathers.

The countries of production are the South of France and the States of Barbary. France produces annually about 2000 quintal. In Africa, exploitations are almost limited to the Province of Oran, which ships every year 15,000 quintals to Oran and 5000 to Mostaganem.

The trade in garouille is influenced by the variations of production of the other tanniferous barks, such as the valonia, quebracho, and myrabolans. Generally the purchasing price of garouille oscillates between 13 and 18 francs the 100 kilogs. in the ports of shipping.

Extraction is rather expensive, but as the kermes are usually on the borders of the sea, the saving effected upon the transports compensates for the high price for extraction.

QUEBRACHO.

In the order of importance of tanniferous barks, we place next the *quebracho*, which has already been dealt with.

It is an excessively hard, red wood, very resistant, and slightly brittle, found in abundance in Brazil and the Argentine Republic.

From a chemical point of view, quebracho contains a special tannin different from those of the oak and chestnut. It contains besides a resin of a violet colour bordering on red and even on black. Treated with water, it abandons 25 per cent. of its weight of soluble matters.

Quebracho colorado contains 16 to 19 per cent. of tannin.
Quebracho blanco „ 12 „ 13 „ „

Besides, it contains colouring matters which it is very difficult to separate, and which are very harmful in its employment, for they give to the leather a disagreeable red tint.

In spite of that, however, Europe actually consumes it to an amount exceeding 6 million francs.

Once ground, quebracho wood rapidly loses in the air its richness in tannin; but if it is in logs, this phenomenon is not produced.

The bark of this wood is not rich in tannin; the useful portion is the red part, which appears when the bark and white sapwood (which is very hard) is removed by the axe.

The tannin of quebracho precipitates the gelatine into clear coloration, the salts of protoxide of iron into ashy grey, and the salts of sesquioxide of iron into dirty green. Concentrated sulphuric acid, added drop by drop, furnishes a rose-coloured liquid.

CHESTNUT-TREE TAN.

Finally, we have to deal with the *chestnut-tree* from the point of view of its exploitation as a tanning matter.

It was in 1888 that the tanniferous property of the wood of the chestnut-tree was discovered. In order to make the extracts the wood of old trees split into logs is employed, which must contain neither rotted nor dead wood, nor small running roots. The logs should be very clean; their length should be between 0·50 m. and 1·50 m. at the most.

The rejected wood is the trunk roots of the tree, which, however, contain most tannin, but this wood is difficult to work, to cut up, and triturate.

The wood of the green chestnut, with 75 per cent. humidity upon the trunk, contains 4 per cent. of tannin.

Ordinary wood with 40 per cent. water contains 6 per cent., and wood completely dry contains from 8 to 9 per cent.

During desiccation a part of the tannin becomes resinified, especially at the commencement. Chestnut trees of the North are not so rich in tannin as those of the South and West, nor as those indigenous to departments of the East.

A hundred kilogs. of wood give 25 kilogs. of extract at 30° Bé., which, theoretically, should be equivalent to 20 per cent. of tannin, though in practice it hardly surpasses 17 per cent. These hundred kilogs. give 10 kilogs. of dry extract comprising 50 per cent. of tannin.

Extract manufactories should naturally be established near the places of exploitation. To make on an average 10,000 kilogs. per day, or 3,500,000 yearly, an annual expense of about 180,000 frs. for general expenses can be relied on; the price of the raw material has to be added to this, which is rather variable, and for which the cost of transportation is about 50 per cent. Everything included, a net price of about 15 frs. per 100 kilogs. of ordinary extract, with 15 per cent. tannin, is arrived at.

The average richness in tannin of the principal tanning material is indicated in the following table:—

	Per cent. of Tannin.
Aleppo galls	60 to 77
Chinese galls	58 „ 77
Smyrna galls	33 „ 60
Bombay cutch	54
Bengal cutch	38
Gambier cutch	38
Sumac (first quality)	16
Sumac (second quality)	13
Dividivi	16
Beblah (Indian galls)	14
Quebracho wood	12 to 19
Chestnut wood	4 „ 9
Bark of young oak	11 „ 13
Bark of pine	8
Bark of fir	4 to 8
Bark of elm	3 „ 4
Bark of alder	3 „ 5
Bark of beech	2

Dosing of Tannins.

There are numerous processes employed to determine the richness in tannin of the substances employed by commerce; we will limit ourselves to pointing out the following:—

A certain weight of tanning matter to be tried is weighed; it is then drained through water, and dilutes to 1 litre with distilled water; 40 c.c. of it is taken, which is precipitated by an excess of acetate of zinc dissolved in an excess of ammonia. The whole is carried to ebullition, then evaporated to a third of the primitive volume; the liquor, after cooling, is filtered; the precipitate of tannate of zinc is thus separated, which is afterwards washed in boiling water, then dissolved in diluted sulphuric acid; a solution of titrated permanganate of potash is added until a persistent rose coloration is proved.

This permanganate solution is titrated by means of a solution of 1 grm. of pure tannin in a litre of water.

If, therefore, 20 c.c. of this tannin solution require 10 c.c. of permanganate of potash, it will be concluded that 1 c.c. of titrated liquor corresponds to a richness in tannin equal to 0·002 grm. If we suppose that the 40 c.c. of liquor may have necessitated the addition of 15 cms. of permanganate, it will be concluded that there was 0·030 grm. of tannin, or for 1000 c.c. 0·75 grm. of tannin.

Specific gravities of tannic acid solutions at 15°:

Specific Gravity.	Acid per cent.	Specific Density.	Acid per cent.
1·0040	1	1·0242	6
1·0080	2	1·0283	7
1·0120	3	1·0325	8
1·0160	4	1·0367	9
1·0201	5	1·0409	10

Employment of Waste Tan.

When the tan has been *spent* it contains only the woody part, and is generally used as fuel.

In general, to employ the tan for this purpose it is compressed when still damp in iron moulds, which transform it into turfs; these are afterwards dried in the open air; they burn slowly, giving plenty of ashes. It is a valuable combustible for poor people, on account of its low price.

It can be admitted that the organic matter of the spent tan presents in a few things nearly the composition of wood, which would give it for dry waste tan the following figures:—

Carbon	0·469
Hydrogen	0·056
Oxygen	0·395
Ashes	0·080
	1·000

The calorific power of this waste tan would be about 4000 calories. Now, that coming out of the pits contains at least 70 per cent. of water. Industrially, it is only employed after desiccation in the open air, or after having been dried by its passage through a rolling-mill press like that represented in Fig. 172, which requires a force of about three horse-power to manipulate it.

In these conditions about 50 per cent. of primitively contained water

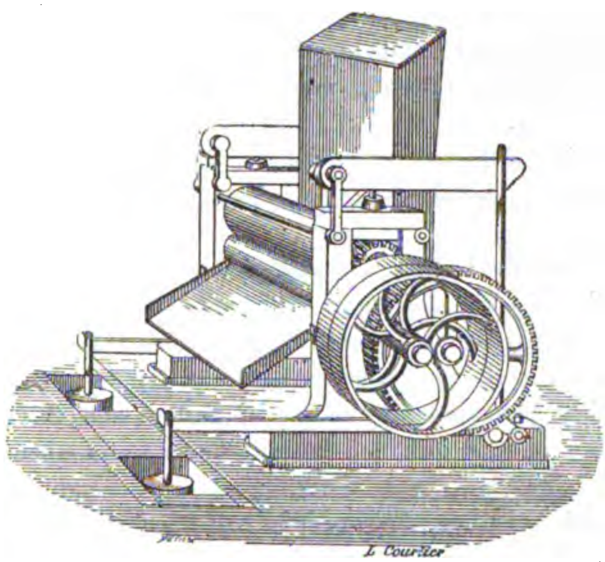


FIG. 172.

is carried off. It is therefore seen that this will never be a very useful combustible, of mediocre interest only in certain special cases, but which requires, for its utilisation, special grates, upon which it is not necessary to dwell here.

APPLICATION OF CORK FOR STOPPERS.

The manufacture of corks dates from the seventeenth century—a time when the use of glass bottles commenced to be widespread in domestic life.

Spain and Portugal are looked upon as being the nations who first utilised their cork-tree forests with this object. Catalonia is regarded as the home of the cork industry, even at the present day holding the first rank from a commercial point of view, its products being greatly in demand.

It has been seen that before the French occupation, the Algerian cork-tree forests were not the subject of any exploitation whatever under

Turkish rule, the natives by no means profiting by the wealth of the forests, the value of which they were ignorant of. Timber, and cork especially, whose commerce was almost unknown, only constituted quite accessory products, which were mostly used as fuel.

To-day all these forests are submitted to judicious exploitations, which permits of their producing excellent results.

Immediately after démasclage the cork which has been gathered is transported to the works. In proportion of the arrivals, the cork is piled up in regular and rectangular heaps; this piling up by submitting the still bent slabs to a certain pressure, flattens them, rendering their manipulation easier.

Before being delivered to commerce, the cork undergoes different operations, namely, *boiling*, *scraping*, *risage*, or *classification*, and finally *packing*.

The object of the boiling is to make the cork swell, to contract the pores, and increase its elasticity. This operation is effected in large rectangular coppers, usually about 6½ ft. in size. They are heated by the *débris* of the cork and roots. Above the copper, a heavy boarding formed of joists is actuated by means of pulleys, and this is intended to press down on the cork and keep it under water when the copper is charged.

To proceed to boiling, the copper is half-filled with water, then the cork slabs are so arranged so as to leave the least empty space possible. When the charging exceeds by 50 cms. the height of the walls surrounding the copper, the boarding is lowered so as to make it form a covering, and the cork is allowed to boil for about three-quarters of an hour; the boarding is then hoisted and the cork taken out, which is almost completely flattened.

Scraping, which follows afterwards, has for its object the clearing of the back of the slab of the woody part of the bark, which is unfit for use and which would charge the cork with useless weight. Scraping is either done by hand or machine.

The corks of first reproduction have still the thick crust, and require longer scraping than those of second and third reproduction. One even finds amongst these latter corks, slabs whose crust is so fine and thin that scraping is unnecessary.

Machine scraping is done with steam by means of horizontal iron bobbins, 25 cms. long by 20 cms. in diameter, swollen towards the middle and furnished on their periphery with small iron blades in the form of combs with short and square teeth.

These bobbins, arranged in pairs, turn with a speed of about 900

revolutions per minute upon a horizontal axis, supported by cast-iron uprights at a height of about 3 ft. 3 in. above the soil.

The cork is submitted to scraping immediately after leaving the copper; the damper it is, the easier is the operation.

The waste produced by this operation is, in weight, from 30 per cent. for corks of first reproduction, 25 per cent. for those of second, and 20 per cent. for those of the others.

Once scraped the cork passes into the hands of the cutter up, who, by the aid of a very sharp chopper, cleanly cuts some portions from the edges of the slab, in order that the *viseur*, or classifier, may judge the quality of the cork. The latter divides the slabs into different categories, according to quality.

This distribution is made into four heaps—thick corks, ordinary corks, bastard corks, and thin or refuse—for the copper. Definite classification is made later, at time of packing.

To bale the cork a rectangular chest without a bottom is employed, about 1·50 m. long, 0·75 m. broad, and 0·60 m. high. Two cords intended to support the corks when it is taken out are placed through the chest, so as to lower to the bottom, and to avoid forcing these cords are arranged in vertical grooves.

One begins by arranging at the bottom, back downwards, one or two good-sized slabs, the length of the chest; this is afterwards filled, arranging the pieces as regularly as possible, so as to leave neither space nor hollows. At the two small ends the corks should be almost cut and well lined, so that the two ends of the bale may be cleanly pared; the fragments, if there are any, are distributed upon the interior; when piling up exceeds by about 20 cms. the edge of the chest, it is covered, as done at the commencement, with one or two good-sized slabs, placed with the back outwards; the two ends of each cord are afterwards joined; the cork thus piled up is drawn together by means of a noose, and the chest is removed by means of handles arranged at both ends. The corded bale is carried under the press to be compressed, then tied or bound.

The classification of cork is a delicate operation, demanding great experience and skill on the part of the classifier. It is of great importance from a sale point of view.

Corks are classed in commerce, according to their thickness, into four categories—

(1) *Thick* corks, measuring 31 mms. and over.
(2) *Ordinary* corks, measuring from 26 to 30 mms.
(3) *Bastard* corks, measuring 23 to 25 mms.
(4) *Thin* corks, measuring 22 mms. and under.

Each of these categories comprises five qualities—superfine, first, second, third, and fourth.

The following are, on the average, the sale prices of the corks:—

	Per metric Quintal. Francs.
Superfine corks and champagne	120 to 150
Demi-champagne	100 „ 110
Superior thick corks	65 „ 80
Ordinary „ „	60
Inferior „ „	45
Ordinary race corks (three first qualities mixed) .	85
„ „ „ (fourth quality) . . .	40
Superior bastard corks	40 to 50
Ordinary „ „	30 „ 35
Inferior „ „	25
Superior thin corks	30
Ordinary „ „	25
Inferior „ „	15 to 20

The cork is transported to the cork-cutting workshop and passes into the hands of a workman, who cuts it up into strips of equal width and length which will make the future cork-stopper. A second workman cuts the strips square having the measurement of the diameter of the cork-stopper; and finally a third workman makes the squares into the cork-stopper, either by hand or machine.

In the Algerian cork works, none but the ordinary cork-stopper is now made. A part of the stopper is made by hand, though the major quantity is made by the aid of a machine resembling a pedal lathe.

The corks are afterwards sorted, weighed, and packed in sacks or bales of 30,000.

It is the custom in some works to whiten the corks; this operation which was formerly made by means of an acid, is to-day replaced by sulphurous fumigation given to the corks after packing.

The following are the principal models of corks:—

	Diameters.	Price per Mille.
	Millimetres.	Francs.
Champagnes	28 to 34	100 according to quality
Demi-champagnes	26 „ 30	50 to 80 „
Long Bordeaux	23 „ 26	30 „ 50 „
Demi-long Bordeaux	...	20 „ 50 „
Lemonades	26 to 28	10 „ 25 „
12 lines, cylindrical	21 „ 25	5 „ 10 „
16 lines, conical	24 over 21	18 superfines
16 lines, cylindrical	24	7 „ 9 fine
18 lines, conical	25 over 22	7 „ 25 according to quality
18 lines, cylindrical	23 to 25	7 „ 25 „
Rolls	10 „ 20	8 „ 12 „

Cork in itself is not hygroscopic, but its medullary canals, full of pulverulent matter, absorb, and retain easily, water and even dampness of the air: hence the variation in the weight of different slabs of cork.

By combustion in a closed vessel of the male cork and the unusable *débris* of the cork of reproduction, a last product of the cork-tree bark can be obtained; this product, known in commerce under the name of "Spanish black," is employed in painting.

CHAPTER XXV.

THE APPLICATION OF WOOD TO THE ART OF DYEING.

UNDER the name of dye-woods is usually designated those containing in their parenchyma colouring matters employed in dyeing, and which are extracted after having reduced the timber to chips or even powder.

A large number of varieties of exotic wood are susceptible of providing colouring matters, but only some of them are applied industrially; these latter only will be dealt with.

LOGWOOD OR CAMPEACHY WOOD.

This wood is furnished by the trunk of the *Hæmatoxylon campechianum*, which is a thorny tree of the Leguminceæ family. It is met with in Southern America, as well as the Antilles. It receives its name from the Bay of Campeachy, in Mexico.

Different varieties of it are distinguished, namely, the logwood of the Spanish West Indies, the English logwood of Jamaica, those of St. Domingo and Hayti; of Honduras, of Martinique, and of Guadeloupe.

Logwood is reddish on the outside, yellowish inside; very dense, of a rather agreeable odour resembling that of the violet.

This wood contains an essence, colouring matter (*hematoxyline*), an azotised substance, resin, acetic acid, chloride of potassium, acetates of potash and lime, sulphate of potash, oxalate of lime, alumina, and oxides of iron and manganese.

One kilog. of logwood extract contains about 125 grms. of pure hematoxyline.

In commerce logwood is found in powder or more often in pieces, and in this latter state extraction of the colouring matter is more easy.

Water only carries away with difficulty the hematoxyline from campeachy wood; 1 grm. of this wood reduced to powder requires, to become

exhausted, about 2 litres of boiling water, and the liquor submitted to evaporation about 0·25 grm. of coloured extract.

Logwood extracts are put on the market which have been prepared by making steam and water act simultaneously on the colouring wood reduced to powder. The water charged with hematoxyline is afterwards evaporated to dryness or to a syrupy consistency; the residue of this evaporation constitutes the extract.

Logwood powder destined for dyeing is often submitted to a treatment the object of which is to increase its colouring power, whilst diminishing the quantity of matters accompanying hematoxyline. The following is the *modus operandi*:—A layer of logwood several centimetres thick is extended over the slabs of a chamber in which a current of air is established. This powder is moistened with water with a watering-pot, then covered by a fresh layer of pulverised logwood, moistened in the same manner before placing on the third layer. These superpositions are continued in this manner until a height of 1·50 m. is attained; at this time the mass is left to itself. The temperature rises rapidly, and fermentation commences, destroying the matters other than hematoxyline. If care be not then taken to establish a current of air in the chamber and displacing from time to time the logwood so as to avoid too high a temperature, the colouring matter would become decomposed inevitably. When the temperature has been well managed, the wood is, at the end of three or four weeks, of a beautiful blood-red colour, and, in spite of all the water it contains, its yield in colouring matter is still equal to $\frac{5}{8}$ of that of the wood not treated.

Hematine or *Hematoxyline* $C_{32}H_{14}O_{12}$ was discovered by Chevreul.

This substance is soluble in alcohol and ether; exposed to sunlight, in a closed vessel, it is coloured red, especially when in a pulverulent state.

Hematine gives beautiful colours under the simultaneous influence of the energetic bases and of oxygen of the air; its savour is sweet; it dissolves slowly in cold water, but very easily in boiling, and can crystallise into prisms with rectangular base.

Baryta precipitates hematine from its solution, giving a bluish-white precipitate passing to violet and then to brown by contact with the air. Acetate of lead forms, with hematine, a white precipitate which, upon contact with the air, rapidly becomes of a blue colour.

Acids, excepting those which are endowed with an energetic oxidising power, exert but little action upon this substance.

Diluted sulphuric acid produces a yellowish-red colour, which becomes yellow by the addition of water. Hydrochloric acid colours the liquor purple red. Very diluted nitric acid reddens the hematine solution.

If it is concentrated, it decomposes the colouring matter, producing oxalic acid. Hematine reduces Fehling's liquor, and deviates towards the right the plan of polarisation; it dissolves easily in saturated borate of soda; the addition of an acid then reprecipitates it in the form of a crystalline mass. Phosphate of soda dissolves hematine in large quantity; hyposulphite of soda dissolves it equally warm, giving it a purple colour.

When hematine is submitted to the simultaneous influence of ammonia and oxygen it is converted into a body called *hemative* $C_{32}H_{10}O_{10}$.

Hemateine is the true colouring principle; it is red, whilst hematine is colourless. Crystallised, it presents a purple colour with metallic reflex. It colours water very deep purple; acetic acid precipitates it from its aqueous solution; sulphuric acid brings it back to the hematine state. Hemateine is dissolved in alcohol, furnishing a liquor coloured reddish brown. It is soluble, in small quantity, in ether, and colours this liquid yellow.

This substance produces, with ammonia, a combination very soluble in water, soluble in alcohol, which is decomposed at 100° by freeing the ammonia.

Hemateine is prepared by dissolving, cold, hematine in ammonia and in abandoning the liquor to contact with the air. Crystals of hemateate of ammonia are soon seen to deposit, which are washed in cold water, then afterwards decomposed by diluted acetic acid.

Commercially, hematine is obtained by treating the logwood with water, then agitating the aqueous extract with alcohol or ether, which carries off the hematine.

In oxidised or fermented wood the proportion of hemateine is found increased at the expense of the solidity of the dye when means of oxidation other than those of air and water are employed to produce fermentation.

Oxidation modifies the solubility of the colouring matter, and this is an important point in textile printing.

Oxidised wood contains from 25 to 30 per cent. of water, non-oxidised wood only 15 per cent.

The price of extracts is often very variable; certain extracts only contain 20 per cent. of colouring matters; the remainder is composed of substances without value for dyeing.

Quantifying the ash is not sufficient to guide the buyer. Certain pure extracts give up to 10 per cent. of ashes, whilst impure extracts give less.

Numerous substances are employed to adulterate logwood extracts,

these are generally molasses, dextrine, sulphate of soda, chalk, and certain extracts of other dye-woods.

Some of these substances are injurious; for instance sulphate of soda weakens the dye-bath and gives an unequal printing colour.

RED OR BRAZILIAN WOOD.

The wood of trees of the genus *Cæsalpinia*, known in commerce under the name *Brazil wood*, contains a red colouring matter which has received the name *Braziline*. These woods, whose value is variable, are the following:—

The *Cæsalpinia christa* is met with in Brazil and also in Jamaica. Its commercial name is *Pernambuco wood*. Its durability is considerable; it is far denser than water, the interior is yellow and the exterior red. This last coloration, owing to the presence of the air, afterwards disappears by the same cause.

The *Cæsalpinia sappan*, or *Sapan-wood*, is very analogous to the foregoing. Reduced to thin pieces, this wood, treated with boiling water, provides a red colouring matter. The aqueous decoction should not be prepared in iron vases, whose action would modify the red colouring matter and transform it into a brownish substance.

Sapan-wood, mixed with a solution of sulphate of copper, gives a remarkable violet colour.

The *Cæsalpinia echinata* furnishes the wood of *St. Martha*, *Nicaragua*, and *Lima*.

The *Cæsalpinia vesicaria*, or of Brazil, is inferior to all the others.

The distinction established between these different kinds of wood arises from the fact that they contain large or small quantities of astringent matters which alter the tint of the Brazil.

These harmful matters can be removed by the addition of a certain volume of milk, which is afterwards heated.

Caseine, by becoming coagulated, carries off the astringent matters, and the supernatant liquid is of a very pure red colour.

The woods of Brazil are distinguished from logwood by their clear tint and by the red precipitate which their infusion furnishes with lime, barytes, and protochloride of tin, whilst these same bodies give with logwood a blue precipitate.

The only characteristic common to these two varieties of wood is of giving an infusion which takes a yellowish tint by the action of sulphuric and hydrochloric acids, and which turns to red when these acids are in excess.

Braziline, discovered by Chevreul, exists in the different kinds of wood just enumerated.

This substance, which is soluble in water, alcohol, and ether, crystallises in small points of orange colour. Alkalies colour it violet purple; acids change this tint into red.

Upon contact with air and ammonia braziline is coloured a deep purple, then becoming brazileine.

Chromic acid oxidises the braziline, forming with it a rather stable coloured compound. Metallic oxides form with it interesting lakes. An infusion of Brazil wood, preserved from contact with the air, is covered by a pellicle which evaporation increases. Braziline can be preserved in water even in contact with the air.

Decoctions preserved for a long time possess double the tinctorial power of that of more recent decoctions.

In order to obtain this colouring matter, the pulverised wood is exhausted with water; the aqueous extract is then evaporated to dryness, in order to expel the free acetic acid which is found there. The residue, taken up again by water, is agitated with lead oxide; the fixed acids are thus saturated. The excess of lead oxide is deposited, and the liquor, which is clear, can be decanted, then evaporated to dryness. It is taken up again by the alcohol, filtered and evaporated, then water and gelatine are added until tannin is no longer precipitated. By evaporating a last time to dryness and straining through alcohol, the braziline is easily carried off, which is crystallised by cooling.

SAUNDERS-WOOD OR SANDAL-WOOD.

Sandal-wood is found in China and Cochin China, also in Gambodge, Java, and the East Indies.

Several varieties of it are distinguished, designated, according to the colour of the bark, under the names yellow, white, and red sandal. This latter is especially useful in dyeing establishments.

Red sandal-wood comes from the *Pterocarpus santalinus*. It is distinguished from the wood of Brazil in that its powder scarcely colours boiling water.

Treated with alcohol, it gives a resinoid red matter designated under the name *sandaline*.

This matter is insoluble in water, but soluble in alcohol, ether, and acetic acid. The solutions are red if the proportion of sandaline is sufficient, and precipitates with the majority of the metallic solutions.

Tin salts, in weak solutions, furnish a purple precipitate; with lead

salts it is violet, then deep violet with salts of sesquioxide of iron, scarlet red with salts of protoxide of mercury, and brownish red with salts of silver.

Boiling alcohol produces, on an average, 17 kilos. of sandaline from 100 kilos. of sandal-wood. It is not then pure sandaline; to obtain it pure, it is necessary to agitate the ethereal extract of sandal with lead oxide, to place the lake produced into fresh ether, and to pass through a current of sulphurous hydrogen; the lead sulphur precipitates, the sandaline remains dissolved in ether, and is separated by evaporation in colourless crystals.

To sandal-wood are allied other woods known, commercially, under the following names:—

Caliatour, or *cariatour*, coming from the Indies; compact, hard, and weighty; superior to sandal.

Wood of *Madagascar*, vinous red.

Barwood, met with in Africa; employed in cotton-dyeing, to which it communicates a highly esteemed red colour.

Camwood, analogous to the preceding.

YELLOW OR CUBA WOOD.

This is one of the most largely employed tinctorial matters, produced by a particular mulberry-tree, the *Morus tinctoria*, native of Brazil and the Antilles.

Yellow or flesh-coloured crystals are met with rather often in this wood, which provide beautiful yellow tints.

Chevreul isolated from the *Morus tinctoria* the colouring principle under three different aspects—*white*, *yellow*, and *red morin*.

This crystalline matter of the yellow wood is composed of two different acids—*moric* and *morintannic acid.*

Moric acid $C_{36}H_{18}O_{17}3HO$, or *white morin*, is barely soluble in water; alcohol and ether, on the other hand, dissolve it very easily. The air colours it slowly a yellowish colour.

It is dissolved, without being coloured, in weak acids. Fuming nitric acid transforms it into oxypicric acid. Sulphuric acid dissolves it and colours it yellow; the heated solution give sulphurous and phenic acids.

Alkalies and alkaline carbonates dissolve moric acid and give a yellow liquid.

Moric acid, in the presence of perchloride of iron, gives a brownish liquor bordering on green.

Moric acid dissolves in water, and is reduced in warm water, and in the presence of potash and sulphate and acetate of copper. A precipitate of anhydrous protoxide of copper is obtained in these conditions. Nitrate of silver, in the presence of ammonia, furnishes metallic silver when the solutions are boiled.

The extraction of moric acid from yellow wood is obtained by diluting, by ten times its volume of water, a boiling alcoholic extract of the wood. Some morate of lime is precipitated; it is collected and dissolved warm in alcohol. Oxalic acid is added to the solution, filtered warm, then mixed with water, which precipitates the moric acid. The acid is afterwards purified by several successive solutions in alcohol, then precipitated by water.

Morintannic acid constitutes with the foregoing the principal colouring matter of the wood engaging our attention.

This acid is presented in the form of a yellow crystalline powder, soluble in water, alcohol, ether, and methylic alcohol. It dissolves at 200° and becomes decomposed at 270°, giving carbonic and phenic acids and pyrocatechine. Chlorine, in the presence of moisture, attacks it actively. Nitric acid transforms it into oxypicric acid. Concentrated sulphuric acid dissolves it cold, it assuming a yellowish tint. The liquor left to itself deposits a crystallised matter of a reddish colour. Morintannic acid heated with a mixture of sulphuric acid and dioxide of manganese, gives carbonic and formic acids.

Finally, morintannic acid throws down sulphate of sesquioxide of iron as a black, copper salts as a blackish-brown, sulphate of alumina as a yellow, and lead acetate also as a yellow, precipitate.

QUERCITRON WOOD.

The bark of the quercitron, or *Quercus nigra*, contains a valuable yellowish colouring matter, designated under the name *Quercitrine* $C_{16}H_7O_9HO$.

This substance, isolated for the first time by Chevreul, is yellow, scarcely soluble in water, but very soluble in alcohol.

Alkalies cause it to pass to green, then to orange yellow. Lead acetate, protochloride of pewter, and acetate of copper precipitate it yellow. Perchloride of iron colours solutions of quercitrine a deep green. Heated in a retort, it sets some vapours free, which become condensed in the form of yellow needles. Distilled with sulphuric acid and dioxide of manganese, it produces formic acid.

Quercitrine is transformed by weak acids into glucose and a yellowish

substance, namely, *Quercitrine.* This latter, which is without odour and savour, does not change by contact with air. It is soluble in water, ammonia, and alcohol.

Quercitrine is obtained by treating the pulverised bark of the *Quercus nigra* by alcohol. The tannin is precipitated by gelatine or lime; the liquor is then evaporated, and the residue is afterwards taken up by the alcohol.

This colouring matter can be equally extracted from the *Capparis spinœa* and the *Sophora japonica.*

FUSTIC.

The *Rhus cotinus*, a shrub of the Terebinthaceæ family, contains in its woody parts a crystallisable substance of yellowish colour, called fustic, and which is largely employed in dyeing establishments.

The colouring matter of fustic is *fustine,* which is soluble in water, ether, and alcohol. These solutions, of an orange-yellow colour, become coloured red under the action of alkalies. Acetates of lead and copper precipitate them yellow.

Pure fustine is prepared by adding a small quantity of gelatine to a decoction of fustic. The tannin precipitates, whilst the colouring matter remains in solution. It is afterwards evaporated to dryness, and the residue, taken up by the ether, is afterwards separated by distillation. It is afterwards treated by water, holding the oxide of lead in suspension; it forms a lake which, decomposed by sulphuric acid, gives pure fustine.

Hoang pe (*Pterocarpus flavus*).—This tree is a native of China, where it grows to a good height. Its bark, which is white on the exterior, is of a bright yellow on the interior. Boiling water extracts from it a colouring matter largely employed in China.

GAMBOGE—TENG HOANG.

The tree producing this substance is met with in Ceylon and in China in the province of Hou Kouang.

To extract it, deep incisions are made in the tree; a viscous matter trickles out, which is gathered a year after the operation. This gum is purified by melting it, the impurities rising to the surface of the bath.

Hanglou (*Dervilla versicolor*).—This tree is also met with in China.

Its wood, treated by boiling water, gives a yellow extract, with which a very beautiful colour is produced, serving to dye imperial stuffs and materials.

PREPARATION OF DYE-WOOD EXTRACTS.

This industry dates from the commencement of last century. The principle of the operations constituting it consists first in removing the colouring water by lye-washing, made with the help of a suitable solvent, according to the wood to be treated, then by concentrating this solution. What are known as "extracts" are obtained in this manner.

One commences at first by dividing the wood into chips more or less fine, often even reducing it to powder. The woody matter should, indeed, be in a good state of division to give more hold to the solvent, which should carry off its colouring matter; sometimes certain limits should not

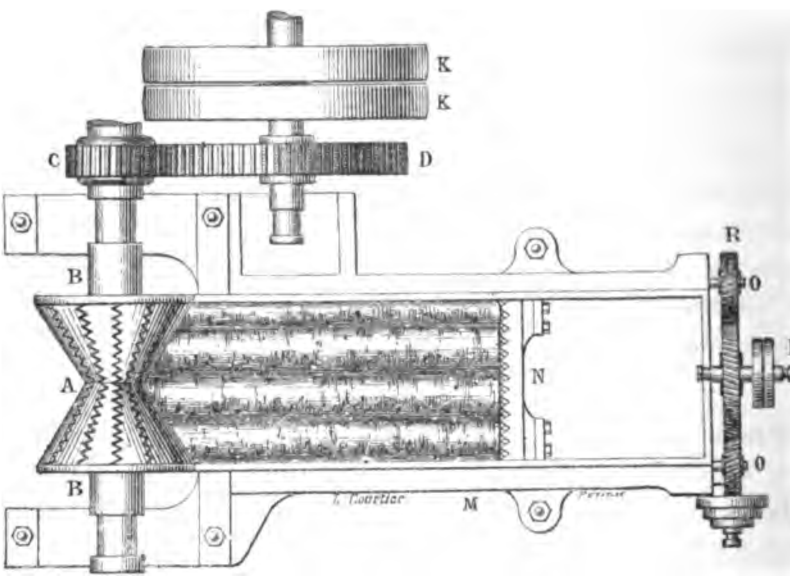


Fig. 173.

be exceeded, so that the woody substance should still preserve sufficient porosity and that draining can be done rapidly.

Different machines are employed to divide the wood mechanically, that represented in Fig. 173 fulfilling well the proposed object. It comprises the following parts:—

A, Destroyer drum, armed with strong knives as sawing blades, which makes the horizontal axle turn in iron B, which is set in motion by gears C, D, and transmission pulleys K.

M, Sheet-iron table which receives the timber to be worked.

N, Movable vehicle provided with teeth so as to press the logs against destroying drum A.

O O, Screws serving to advance the vehicle.

R R, X Y, Systems of gearing and pulleys to actuate the vehicle.

The wood, once divided by this machine, is afterwards submitted to the treatment having as its object the extraction of the colouring matter. For that the copper shown at Fig. 174 is employed.

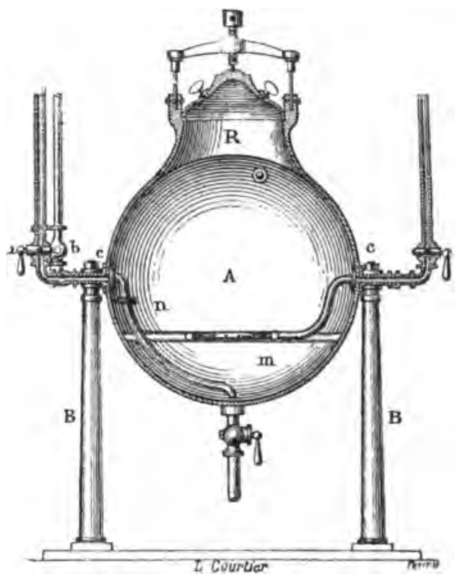


FIG. 174.

Extraction copper A is of copper; it can be oscillated by means of two trunnions *c c*, in which it is mounted on columns B B. To empty it one has only to turn it upside down, then to open the upper man-hole R.

At a short distance from the bottom of this copper there is a double bottom of copper pierced by holes *m*, and carrying a sieve of copper thread. Tube M terminates by a ring pierced with holes, serving to spray the steam vapour. Another tube *n* communicates with two pipes *a*, *b*, provided with cocks. Water can be introduced through *a*; through *b* the liquid charged with colour is drawn off under the influence of the pressure of the steam. The liquid can thus be made to pass from copper A into a second neighbouring copper.

If, instead of draining with pressure, hot water is used, the battery of coppers can be replaced by one of wooden casks, which "see-saw" around their trunnions and are arranged in two parallel lines.

The colouring solutions are more or less charged according to the

temperature of draining and the nature of the wood. They can afterwards be concentrated either with the naked fire, or, better still, by evaporation in a vacuum which permits of operating with more rapidity, and at not so high a temperature and sheltered from the air. Apparatuses analogous to those employed in sugar manufacturing are utilised for that.

DYEING AND STAINING WOOD.

Inversely to the subject just treated, it happens that, industrially, it is to one's interest to give to wood a tint other than that which they naturally possess.

The art of dyeing or coloration of wood consists in fixing upon the vegetable tissue all the colours, as well as their tints and shades, so that they cannot be changed by the agents, to whose action they are habitually exposed. Air and especially light are the most usual causes of deterioration of colours; the extent of this alteration depends on the more or less strong adhesion of the colouring matter upon the woody tissue.

In order to arrange this tissue so as to combine, so to speak, with the colouring matter, it is made to undergo the *scouring* or *bleaching* operation. This previous preparation renders the woody tissue as clean as possible, and has the result of rendering the absorption of the colouring liquid easy and of making the colouring matter adhere to the vegetable fibres. In certain circumstances it has also as its object the bleaching of the woody tissue, in order that it reflects the light less, and that the tints of the colouring matter can thus become purer and more brilliant.

After scouring, the introduction of the mordants is proceeded with. These substances are previously applied to the woody fibres, so as to afterwards make them take the coloration or shade which it is desired to produce, or in order to vary the shades. The mordants thus serve as intermediary between the colouring matters and the woody tissue which it is desired to dye, either to facilitate their combination or to modify it at the same time.

When the wood has undergone these preparations it is perfectly fit to be coloured.

Scouring is not necessary when dark shades or tints are desired; but is always indispensable when it is desired to free the wood from matters which, by their action, would be able to modify or destroy the desired colour.

Thus, for example, tannin being very fit for rendering the colours of

Brazil wood durable, one would abstain from scouring the varieties in which the proportion of tannin is notable, when the presence of this matter will be used as a mordant.

If salts of iron are operated with upon a variety in which the reaction with tannin can be injurious to the tints and shades which it is desired to obtain, it is as well to proceed to energetic scouring.

Injection or impregnation of the colouring substance is made in two manners: either by the aid of a suction or an injection pump.

All the tints applicable to stuffs can be introduced into wood. Annatto, madder, archil, and logwood give different shades of red and violet; litmus and indigo furnish blue colorations; green is obtained by means of acetate of copper; the successive action of the gall-nut and sulphate of iron produces black.

Pear-tree wood can thus be easily dyed by the following process:—

Two parts of pulverised black gall-nut are mixed with fifteen parts of *vin ordinaire*, and the mixture is allowed to settle for some days in a warm chamber. The liquid is afterwards decanted, or it is passed through linen, and then a quantity of water is added to it equal to its volume.

A solution of sulphate of iron in water is prepared in the same manner. If, now, the wood is coated with the first liquid, and then, after having dried, the solution is diluted with sulphate of iron, a beautiful black colour will be obtained, which is the darker as the second solution is the more concentrated.

If it is desired to obtain rapidly a dull lustre, it is necessary to make use of a thin layer of shellac dissolved in alcohol.

A concentrated solution of permanganate of potash is equally well adapted for dyeing wood. This solution is distributed over the surface it is desired to dye, and it is allowed to act until the desired shade has been obtained. In general, some minutes suffice to give a deep shade. Pear and cherry wood are thus very easily dyed.

The action of the mordant consists in the permanganate of potash being decomposed by the vegetable fibres, which precipitate black oxide of manganese which the influence of potash sets at the same time in liberty, and fixes in a durable manner on the fibres. When the action is finished, the objects are carefully washed with water, allowed to dry, and oiled and polished by ordinary means. A very beautiful and stable red colour is thus obtained, for example, upon cherry wood.

CHAPTER XXVI.

DIFFERENT APPLICATIONS OF WOOD—HARD WOOD—DISTILLATION OF WOOD—PYROLIGNEOUS ACID—OIL OF WOOD—DISTILLATION OF RESINS.

The idea of finding a use for certain wastes of wood-working, and notably, for example, of the sawing of wood, is not new. Amongst others, applications of this latter, the calorifuges may be cited which are made in utilising it; but another application of sawdust, and one which is most interesting, is that which consists of making hardened wood.

The idea of agglutinating sawdust and thus obtaining different objects dates back to the last century.

Early in the last century there were, in certain amateurs' cabinets, medals and other objects obtained by taking a hollow mould and filling this with moist sawdust in a clear paste, then making the whole of it undergo a certain pressure.

But this mode of agglomeration of the sawdust has been greatly improved since by employing blood albumen.

FABRICATION OF HARD WOOD.

At the present time wood is hardened in the following manner:—

Wood sawdust, especially that of violet ebony, is reduced to a very fine powder, then moistened with sufficient blood mixed with water, and carried to a stove heated to about 50^{c}. It is with this dried dust that the blood albumen combines. The sawdust used is all of the same wood. Grinding is done in rings containing some matrices in polished steel, intended to reproduce, with all the *finesse* possible, different artistic creations.

The dried dust is piled into the moulds in such a manner that, after compression, there may not be any excess of the raw material.

Pressure is obtained by means of a very powerful hydraulic press.

The plates are heated by gas in such a manner so as to maintain a uniform temperature during the whole of the operation.

The moulds provided with their rings are worked in grooves arranged so that they cannot undergo any variation.

The heating plates are each provided with a gas apparatus, which follows their movement of ascent or descent.

At first it is difficult to render an exact account of the action exercised by the albumen of the blood upon sawdust. It has for a long time been believed that this action was the same as that produced upon the tissues by egg-albumen. But an examination of the sawdust thus worked causes the presence of resin to be recognised. It has been recognised that resin, in presence of blood albumen, causes very strong adherence. Heated towards 200°, the blood, by commencing to fuse, acquires such an adhesive property that, after cooling, its parts have preserved notable adherence. This heating operation can be considered as a sort of fusion, for if the moulds are opened during working, a soft, blackish, semi-liquid paste will be found, so to say, analogous to bitumen in fusion. It is probably at this moment that the most delicate parts of the matrices are filled and faithfully reproduced after cooling.

In manufacture made with violet-ebony sawdust, a rather interesting phenomenon is produced. The air is expulsed, and the mixture of sawdust and blood albumen undergoes fusion. A new matter is formed resembling woody tissue, and a hard and dense wood is obtained capable of undergoing all cabinetmaking-work.

This phenomenon appears to be due to the simultaneous action of the resin contained in the sawdust and of the blood albumen in the presence of heat and pressure. The matter acquires a blackish-brown tint, and, after cooling, its density reaches 1·300, whilst the albumenised sawdust only weighs 0·800.

The objects thus moulded can be polished and varnished and made to receive incrustations of ivory or mother-of-pearl.

DISTILLATION OF TIMBER.

Among the industrial applications of timber must be ranged the products resulting from their distillation, namely, gases, oils, and other condensable products, the most important of which is pyroligneous acid. Coal will not be spoken of, its study not entering into our programme.

It was Lebon who first submitted wood to rational distillation with the object of extracting lighting gas from it. It is known that his attempts were at first fruitless. He had, however, since his first experi-

ments, discovered pyroligneous acid, tar, and inflammable gas in the condensed products of distillation.

In 1869 Pettenkoffer recognised that carbonisation of wood, worked at low temperature, gives dimly-lighting gases, poor in hydrocarbides, but that, if decomposition is effected at a cherry red-heat, one can obtain in large quantity hydrocarbides accruing from the decomposition of the condensable vapours. These hydrocarbides, purified, are more brilliant than coal gas. Hence a new industry which is established in a number of towns.

All kinds of wood have been experimented with, and it has been recognised that their variety is almost indifferent to the result obtained as to the production of gas.

Thus it is that with quick calcination it has been found that 100 kilos. of wood of different kinds could give the following average quantities of gas:—

	Cubic Metres.
Fir	38·0
Pine	32·5
Oak	34·0
Beech	33·0
Birch	35·0
Larch	31·0
Lime	37·0
Willow	37·0

The degree of desiccation of the wood exercises, on the other hand, great influence upon the gas products obtained. Any kind of wood can be worked with, provided it be very dry; for if, during distillation, the water vapour passes over the incandescent charcoal, carbonic oxide, in large quantity, and hydrogen are formed, which are highly injurious to the lighting power.

Two samples of production, one with half-dried wood containing 8 per cent. of water, and the other with the same wood dried to 160°, gave the following results:—

	Dry Wood. Cubic Metres.	Damp Wood. Cubic Metres.
Quantity of gas produced	33·00	31·00
Carbonic acid present before purification	5·21	6·92
Duration of distillation	60 minutes.	75 minutes.

One is therefore inclined to dry the wood before distilling it by the heat lost from the furnaces, by arranging behind the latter a stone-work chamber which serves as a stove.

Underneath the sole of this chamber, which is lined with cast-iron, the

combustion products of the ovens are made to circulate before directing them into the chimney. The wood is piled up in this chamber and is allowed to stop there for at least twenty-four hours. It is afterwards taken away to fill the retorts, which serve in the distillation.

These retorts are of cast-iron; they are similarly shaped as those employed in the distillation of coal.

Their dimensions are variable: the small ones may receive 50 kilos. of wood and the largest 75 kilos.

Earthen retorts are generally recognised as being the most convenient for the distillation of coal; it is not the same with wood; cast-iron is then preferable.

The following are the dimensions adopted:—

	Small Retorts.	Large Retorts.
	M. M.	M. M.
Height	0·30 to 0·35	0·43 to 0·45
Width	0·56 „ 0·60	0·65 „ 0·68
Length	2·60 „ 2·70	2·60 „ 2·70
Thickness of walls	0·025 „ 0·030	0·037

For small retorts the production of gas can be estimated, in twenty-four hours, at 240 cubic metres as a maximum; the large ones may give 300 cubic metres. Generally, an oven contains only three retorts. The grates are similar to those employed in coal gasworks; they can also be heated by gasogenes.

The progress of distillation is very rapid, especially at the commencement; the operation lasts an hour and a half.

The following figures show the progress of distillation:—

	50 kilos. of Fir. Cubic Metres.	50 kilos. of Pine. Cubic Metres.
Gas collected during the first quarter of an hour	7·86	5·93
„ „ second „ „	5·88	5·15
„ „ third „ „	3·50	3·41
„ „ fourth „ „	0·84	1·91
„ „ fifth „ „	0·05	0·16
„ „ sixth „ „	0·00	0·03

Distillation once finished, the retorts are opened so as to extract the charcoal which is put into the sheet-iron apparatuses, which are closed and cooled.

Coming out of the retorts, the gas passes into a box presenting a special arrangement, as represented in Figs. 175, 176, and 177, and which realises the double condition of having an hydraulic joint and of being cooled by water.

II is the hydraulic main, carrying the small muffle tubes RRR

which receive the disengaging pipes of the retorts. The fourth tube corresponds to pipe W, through which the gas escapes. A cast-iron case K K, completely filled with water, surrounds the main, which is thus immersed in water, which is constantly renewed. The small cast-iron

Fig. 175.

plates $a\,a'\,a''$ are intended to moderate the oscillations of the liquid in such a manner that the immersion of the pipes R R R may be almost constant. This precaution is indispensable on account of the great pressure attained by the gas—a pressure which might even exceed 30 cms. of water.

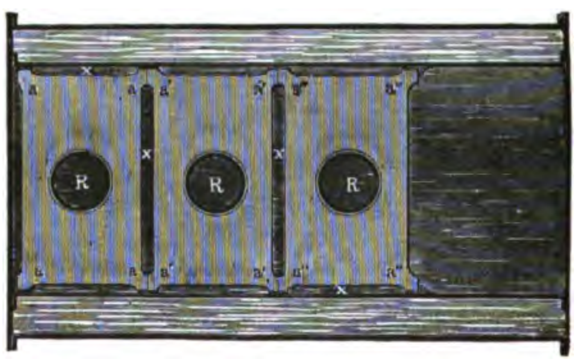


Fig. 176.

In the main chamber the tar and pyroligneous acid deposit. The supernatant liquid flows through the syphon S.

Purification is done with slaked lime. The lime absorbs carbonic acid, which forms a quarter or a fifth of the volume of the gassy mixture, and retains the acetic acid portion, which is not condensed, as well as the phenol.

The principal inconvenience of this manufacture is the large quantity of lime rendered necessary. This consumption is, moreover, rather variable; it oscillates between 90 kilos. and 120 kilos. for 100 cubic metres of purified gas.

Gas produced by the distillation of wood, like that of coal, is a mixture of oxide of carbon, hydrogen, and different hydrocarbides, amongst which may be cited acetylene, olefiant gas, propylene, benzene, toluene, xylene, etc.

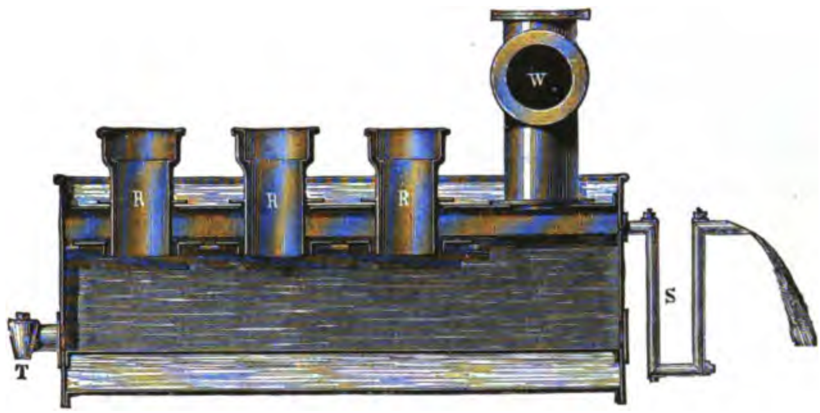


FIG. 177.

These quantities are very variable. The following results have been proved for the distillation of the fir:—

	In Weight.
Oxide of carbon	61·8 to 22·3
Hydrogen	48·7 „ 18·4
Heavy hydrocarbides	10·6 „ 6·5
Light „	35·3 „ 9·4

The specific gravity of wood gas is lower than that of air, varying from 0·6 to 0·7. It follows that the air will penetrate a current of this gas more easily than that of pit-coal gas; it also follows that it is necessary to increase the size of the gaseous jet which burns in order to prevent its being penetrated by an excess of air, which would prevent its combustion. *Butterfly burners* should therefore be used for the utilisation of this gas, giving to them a width of about 1 mm.

The secondary products of wood distillation are the waters charged with tar and coal. (Pyroligneous acid will be specially dealt with a little further on.)

The waters are condensed in the rundlet and the refrigeratories. They are gathered, and then left to settle in the wooden casks, where the tarry waters are separated from those that are acid. These latter are saturated by lime, which gives acetate of lime, whose commercial value is rather high. The tar is also easily sold.

Soft wood is generally utilised for this distillation, for the charcoal issuing from it burns quickly and easily; it is highly appreciated in domestic economy.

The gas of the wood does not contain any sulphurous products, which is often an appreciable advantage.

The cork waste produced in cork manufacturing can also, by distillation, give a very good lighting gas.

The bye-products of this special distillation are separated into two layers: the one, which is aqueous, with slightly acid reaction; the other, which is constituted of a very fluid deep reddish-brown tar.

This aqueous liquid contains, as principal products, acetic acid, methylic alcohol, and, moreover, a considerable proportion of ammonia, which greatly neutralises the acid.

The accessory products are: hydrocyanic acid and homologues of acetic acid, amongst which are propionic acid, and a small quantity of methylamine.

Tar is heavier than water. Its odour is very aromatic, and its very simple distillation furnishes the following products:—

Light oil collected at 210°	27
Heavy oil, brown	27
Oil with green fluorescence	11
Pitch and loss	35
	100

The least volatile portions of light oil leave by cooling plenty of naphthaline. This heavy oil, treated with soda, does not diminish in volume. Sulphuric acid is almost without action on it.

Cork tar contains at least 4 per cent. of benzine and 3 per cent. of toluene. Heavy oil, treated with soda, provides little phenol.

As for the oil with green fluorescence, which is obtained when distillation is driven at a temperature of at least 350°, it contains notable quantities of anthracene.

Cork therefore gives products analogous to those issuing from the distillation of hard wood, but it does not supply the remarkable series of phenolic bodies.

M. Senf published, some years ago, some interesting results of experiments as to the distillation of wood.

The trials have been made on small quantities, but realised in conditions as near as possible the industrial labour.

The apparatus employed is composed of a cast-iron retort of 0·60 m. long by 0·20 m. in diameter, arranged horizontally in a small furnace. The worm where the products of distillation are condensed was rather long and well cooled by a bath of fresh water.

The gas which is formed, and separated from the liquid products by

a syphon fixed to the lateral wall of the reservoir of the liquid, escapes by a pipe at the end of which it was enflamed or collected.

It has been sought, in these experiments, to compare the yields furnished by the different timbers, by different parts of the same tree, and, finally, by the same healthy or diseased wood. The comparison has also been aimed at of the yields of one same kind of wood by rapid or economical calcination.

The wood has always been calcined with its bark, as in the case of the industrial treatment. It was divided into fragments of 0·20 m. long by 2 to 3 cms. thick, then dried by exposure in the air at the ordinary temperature.

In each case procedure was made successively both by rapid and slow distillation.

The first was performed by bringing at once the retort to red heat, then by introducing at once all the wood to be calcined, during the whole operation it being kept at red heat.

This rapid distillation required three hours; slow distillation was effected in double that time.

The following table gives the results to which these experiments have led:—

Variety of Wood.		100 kilos. of Wood dried in the Air have given—						
		Total of Distilled Products.	Tar.	Acetic Acid. Rough.	Acetic Acid. Retension of Acid per cent.	Radical Acetic Acid.	Dry Wood Charcoal.	Non-condensed Gas.
Carpinus betalus, healthy trunk	m	52·40	4·75	47·65	13·50	6·43	25·37	22·23
	n	48·52	5·55	42·97	12·18	5·23	20·47	31·01
Rhamnus frangula, small divided trunks	m	52·79	7·58	45·21	13·38	6·05	26·50	20·71
	n	45·38	5·15	40·23	11·16	4·49	22·53	32·09
Alnus glutinosa, healthy trunk	m	50·53	6·39	44·14	13·08	5·77	31·56	17·91
	n	47·76	7·06	40·70	10·14	4·13	21·11	31·13
Betula alba, healthy trunk	m	51·05	5·46	45·59	12·36	5·63	29·24	19·71
	n	42·98	3·24	39·74	11·16	4·43	21·46	35·56
Sorbus aucuparia, healthy trunk	m	51·54	7·43	44·11	12·60	5·56	27·84	20·62
	n	46·40	6·41	39·97	10·41	4·16	20·20	33·40
Fagus sylvatica, healthy trunk	m	51·65	5·85	45·80	11·37	5·21	26·69	21·66
	n	44·35	4·90	39·45	9·78	3·86	21·90	33·75
Fagus sylvatica, healthy branches	m	49·89	4·81	45·08	11·40	5·14	26·19	23·90
	n	43·14	2·90	40·24	10·89	4·38	21·30	35·56
Populus tremula, healthy trunk	m	47·44	6·90	40·54	12·57	5·10	25·47	27·09
	n	46·36	6·91	39·45	11·04	4·36	21·33	32·31
Fagus sylvatica, diseased branches	m	51·31	3·56	43·75	10·08	4·81	23·23	25·46
	n	47·32	5·99	41·33	8·88	3·67	20·98	31·70
Quercus robur, healthy trunk	m	48·15	3·70	44·45	9·18	4·08	34·68	17·17
	n	45·24	3·20	42·02	8·19	3·44	27·73	27·03
Pinus abies, healthy trunk	m	45·37	4·42	40·95	6·66	2·73	30·27	24·36
	n	51·75	9·77	41·98	5·70	2·39	24·18	24·07
Pinus abies, diseased trunk	m	46·92	5·93	40·99	5·61	2·30	34·30	18·78
	n	46·35	6·20	40·15	4·44	1·78	24·24	29·41

The figures of series *m* accrue from slow distillations, those of series *n* from quick distillations.

It can be concluded from these different experiments that the yields in pyroligneous acid, tar, charcoal, and gas are only slightly different, whatever the variety of wood may be.

But, on the other hand, the richness of the water in dehydrated acid varies greatly; in this respect, folious wood is richer than resinous.

PYROLIGNEOUS ACID.

When one has for his main object the collecting and utilising of the gas product by distillation, the pyroligneous acid is generally made by means of the apparatus represented in Fig. 178.

This apparatus is composed of a sheet or cast-iron cylinder D of a

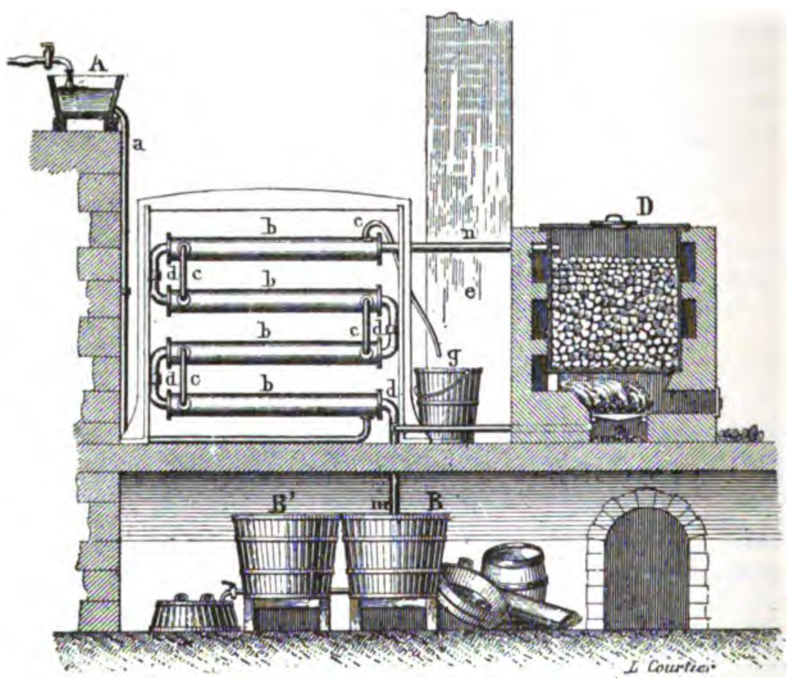


FIG. 178.

capacity equal to about 4 cubic metres, intended to receive the wood previously divided into logs which are introduced through an aperture made in the cover. This cylinder is found above a grate, in which the combustible is charged through a lateral door. Before proceeding to the draught chimney, the flame circulates around cylinder B, passing through several small holes in the stone work. The cylinder communi-

cates by a pipe *n* with a condensing apparatus, comprising a series of horizontal pipes *d d d*, enveloped by tubes *b b b*, in which a current of cold water constantly circulates, led through tube *a* and issuing from a reservoir A. This water first penetrates into the lower tube, to proceed afterwards, through conduits *c c c*, into the other tubes. The warm water goes out through the overflow *g*.

The gases accruing from wood decomposition are directed through tube *b* under the cylinder D, where they are kindled and contribute towards the heating of the apparatus.

The condensed empyreumatic liquids flow through pipe *m* into vats B B′. The coal is withdrawn at the end of about six hours through a door at the bottom of cylinder B.

The liquid thus condensed is composed of water, tar, methyl alcohol, ether, and acetic acid.

It is freed from the tar floating on the surface, and is then introduced into a copper alembic. The wood spirit, or methylic alcohol, is found in the first products of distillation.

Coarse or pyroligneous acetic acid passes afterwards.

This acid is afterwards coloured, and possesses a tarry savour which fresh distillation is unable to remove from it. In order to completely disinfect it, one is obliged to combine it with a base. Sometimes carbonate of soda is employed for that purpose; it is, however, more economical to first treat the acid by carbonate of lime, then to decompose by sulphate of soda the acetate thus obtained. Sulphate of lime is precipitated, and the acetate of soda is purified by crystallisation.

The acetate is afterwards treated by sulphuric acid, diluted by half its weight of water. The acetic acid is received into condensing apparatuses, where it liquefies; it is finally purified by a second distillation.

As the sulphate of soda formed in this reaction is insoluble in acetic acid, it is precipitated under the form of crystals, and can be separated by decantation.

The pyroligneous acid thus made only contains traces of sulphate of soda which fresh distillation can completely purify.

Different kinds of wood, as has been already shown by the previously-cited experiments, provide variable proportions of pyroligneous acid.

Modifications have been proposed with the object of making this manufacture more economical. It is in this way that the rough products of the first distillation can be immediately saturated by lime. A part of the tarry matters combines with the lime and the other remains

in the liquor. When this latter is made clear by depositing or filtration, it is evaporated in a cast-iron copper until reduction of the volume to a half. It is afterwards acidified with hydrochloric acid, which decomposes almost the whole of the combinations which the lime had formed with the tarry matters; these latter float on the top, and can be easily carried off.

The acetate of lime is afterwards dried, and is then distilled with hydrochloric acid. When a very pure acid is desired, a second rectification by carbonate of soda or bichromate of potash is proceeded with; this latter salt has the advantage of destroying the odorous matters which the pyroligneous acid still contains.

Another process of purification consists in treating the crude acid with sulphuric acid in small quantity; this latter determines the separation of the tar. It is allowed to settle for twenty-four hours, and then distilled. The acetic acid thus obtained is colourless, does not blacken on contact with the air, and no longer deposits empyreumatic matters. It is then saturated by carbonate of soda and is then evaporated; the acetate of soda obtained is purified by a new crystallisation.

Barytes might also be employed. The rough acid is saturated with carbonate of barytes or sulphide of barium. An acetate is thus obtained which is afterwards roasted with moderation so as not to decompose it. This acetate of baryta is afterwards decomposed by sulphuric acid. Sulphate of barytes and weak acetic acid are obtained. The acetate of baryta can also be transformed into acetate of soda by a proportionate addition of sulphate of soda.

WOOD OIL.

Among the branches of industry successfully established in Sweden, that of wood oil occupies an important place. The shoots are utilised in this manufacture, as well as the roots remaining in the ground when the forests have been felled.

These raw materials are submitted to dry distillation, that is to say, they are heated in retorts protected from the air. The different matters just dealt with are collected in this manner, and besides a special oil employed for lighting purposes. As this oil contains a large quantity of carbon, it requires special lamps, slightly different, however, from those employed in the burning of mineral oil. It is the least costly illuminating oil, and there is no danger of explosion arising from its use.

This oil is generally produced by the distillation of the pine and fir.

DISTILLATION OF RESINS.

We will close these considerations as to the industrial applications of wood and of its derivatives by some accounts concerning an industry which, in certain circumstances, may have a great interest, namely, the distillation of resins.

Generally, the object in view when resins are distilled is to extract from them the illuminating gas and to collect, at the same time, the light oils, easy of sale.

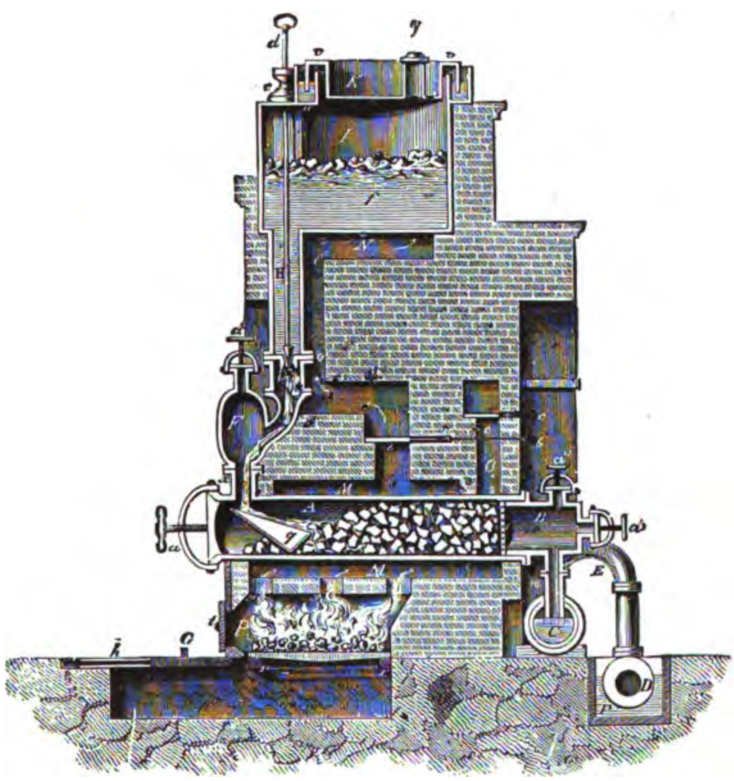


FIG. 179.

A good apparatus employed with this object is that bearing the name of M. Chaussenot, and shown at Fig. 179.

A hearth P, whose draught is regulated by a register Q, is provided with a vault pierced with holes *g g g* through which the flame rises, which surrounds the retort A, then proceeds to the chimney after having traversed M N, which surrounds the resin reservoir I. Register *b* serves to isolate this part from the enclosure N when it is desired to fill the reservoir; in this case, register *b* is closed and the warm gases escape directly into O.

The resin introduced into reservoir I settles and flows through the conduit H and the conical valve G in order to arrive, through the opening x, in the retort A, where a certain quantity of coke is found. A framework l separates the retort into two parts, and the gas produced passes to the rear into B, thence into the tar reservoir C, and finally into the refrigerator D.

It is thus seen that this apparatus is capable of continuous distillation, which continues until the time when the carbon deposits in the retort become sufficiently bulky for it to be necessary to carry them away.

Resin gas is not so good an illuminant as oil gas, though it is, at any rate, as good as coal gas. Generally, 1 kilog. of ordinary resin supplies from 800 to 1200 litres of gas.

THE END.

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